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The SCIENTIFIC MONTHLY

October 1944

CONTENTS

World Maps	*Rear Admiral G. S. Bryan*	245
The Problem of Organic Form II & III	*S. J. Holmes*	253
Science in French Canada II	*Pierre Dansereau*	261
Evolution of the Wheel	*H. E. Kleinschmidt*	273
Economic Entomology in South America	*Edson J. Hambleton*	283
The Principle of the Unobservable	*H. M. Dadourian*	293
The Great Aryan Myth	*Knight Dunlap*	296
Convenience and Convention in Rearing Children	*Leo Kanner*	301
Secondary Education in Britain	*T. D. A. Cockerell*	307
Science on the March		313
Book Reviews		315
Comments and Criticisms		321
Meet the Authors		iii

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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

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IN 1848, on September 20, the Association was formally organized and held its first meeting; in 1874 it was incorporated under the laws of the Commonwealth of Massachusetts and given the right to receive, purchase, hold and convey property. Its governing body is a Council, now having 255 members.

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MEET THE AUTHORS

REAR ADMIRAL GEORGE S. BRYAN, United States Navy, although placed on the Retired List in 1941, was continued on active duty in charge of the Hydrographic Office. He was promoted to the rank of Rear Admiral in 1942 and is still on active duty as Hydrographer of the Navy in Washington, D. C. Admiral Bryan was born in North Carolina in 1884 and graduated from the U. S. Naval Academy in 1906. His first sea duty as Assistant Navigator of the Battleship *Illinois* aroused his interest in navigation and charts—an interest that never waned. At the outbreak of World War I he was in command of a gunboat up the Yangtze River. When his ship was interned, he went on the staff of the Commander-in-Chief, Asiatic Station, and was in Vladivostok during the disturbances there. After the war he carried out various duties as a naval officer on various ships in different parts of the world. In 1935–36 he was Commanding Officer of the U.S.S. *Maryland*. His opportunity to delve into his favorite subject, charts, came in 1937, when he was ordered to the Hydrographic Office. During the past year over 43,000,000 charts, including aviation charts, were produced by his Office for the armed services. The Admiral admits a fondness for athletics, bridge, and poker.

S. J. HOLMES and PIERRE DANSEREAU: see pages vi and iii, respectively, in the preceding issue.

H. E. KLEINSCHMIDT, M.D., is Medical Director, American Red Cross, North Atlantic Area, and resides at 128 Ryder Road, Manhasset, New York. He was born in St. Louis in 1884, took his M.D. from Washington University in 1909, and remained in St. Louis practicing medicine until 1917. For fourteen years he served as Director of Health Education, National Tuberculosis Association. Throughout his career Dr. Kleinschmidt has enjoyed making things. He has spent many happy evenings in his cellar workshop making models of ships and vehicles. Thus he developed his interest in the origin of the wheel, and in the course of his extensive travels, he always kept a weather eye open for primitive vehicles, collecting data and photographs and making sketches. His house is cluttered with ships and carts, wagons and coaches, which neighborhood kids love to see. Piano music and gardening round out his diversions. He has made educational movies too.

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Readers of *Life* and *Fortune* have seen examples of Harrison's graphic global maps which are collected in this atlas. Azimuthal equidistant, orthographic, and gnomonic projections are given also. This atlas is an excellent substitute for a large globe.

Dana's System of Mineralogy. CHARLES PALACHE, HARRY BERMAN and CLIFFORD FRONDEL. Illus. 834 pp. 1944. $10.00. John Wiley & Sons, Inc.

The 7th edition of this book deserves notice because it represents the present version of an important book that was first published more than one hundred years ago. For the publisher it is a centennial edition. This book and the two volumes to follow are the mineralogists' handbook.

Ancient and Medieval Dyes. WILLIAM F. LEGGETT. vi + 95 pp. 1944. $2.25. Chemical Publishing Company.

This fascinating little book tells the story of the animal and vegetable dyes that were used long before coal tar dyes were known. Of particular interest is the account of Tyrian purple, the royal dye of the ancients.

The Economics of Control. ABBA P. LERNER. vii + 428 pp. 1944. $3.75. The Macmillan Company.

A graduate of the London School of Economics, the author presents his thesis of economics in a society that is neither socialistic nor capitalistic exclusively, but is subject to governmental control of economic life.

The Romance of Existence. ROSS BUNDY. Illus. iv + 188 pp. 1944. $2.00. The Pitman Publishing Co.

The author has attempted the difficult task of writing a short story of the earth and the development of life on earth. Sprinkled through the book are quotations from British poets. The book is intended to stimulate reflections on the existence of man.

Foreign Maps. EVERETT C. OLSON and AGNES WHITMARSH. Illus. v + 237 pp. 1944. $4.00. Harper and Brothers.

In this book one will not find many maps, but he will find information that will help him to interpret maps produced by foreign countries. Much of the book is devoted to glossaries of foreign geographical names, including Oriental and Slavic languages.

Science in the University. Members of the faculties of the University of California. 1944. 332 pp. Illus. $3.75. Univ. of Calif. Press.

As a token of gratitude to the taxpayers of California, this book presents to its citizens samples of the scientific work and thought of the leading scientists of the University of California. Nineteen scientists have contributed.

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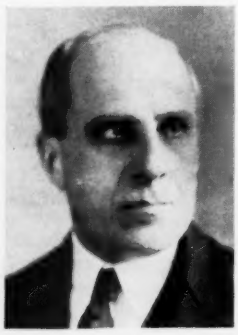
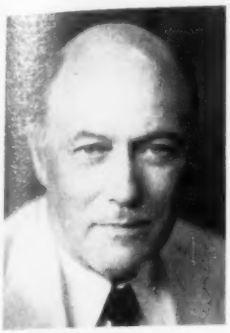
MEET THE AUTHORS, Continued

EDSON J. HAMBLETON, M.S., recently became Senior Entomologist in the Office of Foreign Agricultural Relations, U. S. Department of Agriculture, Washington, D. C., dealing with entomological problems in Latin America. He was born in Columbus, Ohio, in 1902 and was reared on a farm in central Ohio. His undergraduate work was done at The Ohio State University and his graduate work at Cornell. In 1929 he went to Brazil as Professor Cathedratica de Entomologia at the Escola Superior de Agricultura in Viçosa, Minas Geraes. In 1934 he became Entomologist at the Instituto Biologico at São Paulo, devoting most of his time to cotton insect investigations. In 1939 he went to Peru as Entomologist for the Sociedad Nacional Agraria at Lima, again concentrating on cotton insects. Having spent fourteen years below the equator, Mr. Hambleton is able to write authoritatively on the unique pest control problems of subtropical South America.



H. M. DADOURIAN, Ph.D., is Seabury Professor of Mathematics and Natural Philosophy at Trinity College, Hartford, Connecticut. He was born in Everek, Asia Minor, in 1878 and went to an American school, St. Paul's Institute, at Tarsus, Turkey. Arriving in this country at the age of twenty-two, he entered Yale University, graduated in electrical engineering, and went on to take advanced degrees in physics. He remained at Yale on the physics faculty until World War I, when he served in the U. S. Signal Corps in research on sound-ranging. After the war he began his present work at Trinity College. Since boyhood Professor Dadourian has been interested in international affairs, in social and economic problems, and in the application of the scientific method to general public welfare. He has written and spoken in public on such subjects. He is interested also in mountain climbing, gardening, and tinkering.

MEET THE AUTHORS, Continued



KNIGHT DUNLAP, Ph.D., is Professor of Psychology in the University of California at Los Angeles. He was born in 1875 in the old gold-rush district near Placerville, California. He spent the first thirty years of his life in central California, the second thirty years in Maryland, and hopes to complete the third thirty in southern California. Brought up on a ranch, he had to study by himself to prepare for entrance into the University of California at Berkeley. Graduating from Berkeley in 1899, he took his Ph.D. in psychology at Harvard in 1903. Professor Dunlap made his professional reputation at Johns Hopkins in psychology and anthropology. In the latter subject he gave the first course ever offered at Johns Hopkins. During what he calls the first phase of the war, up to 1918, he was attached to the Air Service Medical with rank of major. In the present second phase of the war, his age alone prevents him from wearing a uniform, but he wishes he were a gob in the Navy.

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LEO KANNER, M.D., has been Associate Professor of Psychiatry in the Johns Hopkins University School of Medicine since 1933. He was born in 1894 in Klekotow, at that time the easternmost point of the Austro-Hungarian Monarchy, and took his M.D. at the University of Berlin in 1919. At first he specialized in internal medicine. A few years after coming to the United States in 1924, Dr. Kanner began his work in psychiatry. In 1930 he established the Children's Psychiatric Service of the Johns Hopkins Hospital. He also served as psychiatric consultant to the Baltimore City Juvenile Court. He is the author of four books and has published approximately 130 articles dealing with internal medicine, psychiatry, psychology, education, history and folklore of medicine. His two children are well adjusted, contrary to popular opinion of the offspring of psychiatrists.

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MEET THE AUTHORS, Continued

T. D. A. COCKERELL, hon. Sc.D., is Professor Emeritus of Zoology at the State University of Colorado at Boulder. Born in England 78 years ago, Professor Cockerell has had a distinguished career in zoology and entomology—too long and varied to be described here. Instead we shall mention certain incidents in the life of Professor and Mrs. Cockerell, for the latter is also a biologist and has worked closely with her husband. Free from the routine of teaching, they temporarily took charge of the Desert Museum at Palm Springs, California, where last winter and spring they had over 13,300 visitors, many of them soldiers. For a number of years the Cockerells spent their summers at Florissant collecting fossil insects, among which was a fossil butterfly found by Mrs. Cockerell and one of the very few known to science. Another remarkable discovery made by Mrs. Cockerell was a red sunflower, a mutation growing by the roadside in Boulder. It was removed to the garden (*below*) and developed into a series of forms, with beautiful and interesting colors, now grown around the world. In 1923 the Cockerells went to Siberia in search of recent and fossil insects. On their ship they witnessed the destruction of Yokohama by the great earthquake. Professor Cockerell's present paper stems from Mrs. Cockerell's gift of a thousand copies of her husband's zoology textbook to the British Board of Education. They have also sent to England natural history films for use in schools and for the armed forces. The first one sent over went to the Princess Elizabeth, and brought a letter from the Queen. A recent colored picture of the Canadian Rockies, made by Guy Haselton, is to be shown to all the Canadian units in Britain.

THE SCIENTIFIC MONTHLY

OCTOBER, 1944

WORLD MAPS

By REAR ADMIRAL G. S. BRYAN

THE average man has never taken his geography very seriously. It is a subject which he completed in his elementary schooling and then packed away in moth balls to be resurrected only when something important happened somewhere and he wanted to know where that particular spot was.

Something important has happened in a good many unheard of places in the past few years. Attu, Guadalcanal, Tobruk, Chungking, Kharkov, Truk, Salerno, and numerous other names have made headlines which have left the average man in a geographical daze. The result has been a revival of interest in geography and a desire not only to find out something about each of these places but also to visualize these various theaters of operation in their proper relation with each other so as to give a broad general view of the conduct of the whole global war. In short, the public is now brushing up on its geography and is paying particular attention to the study of *world maps*.

Cartographers have recognized this trend and have been examining the situation to determine what can be done to improve present world maps. A number of discussions on the subject have been published recently in books, magazines, and even advertisements. Some of these articles are very good; others show a startling lack of fundamental understanding of the subject. Nearly all the latter condemn the most popular world map, the Mercator (Fig. 1), as obsolete, but few of them have anything new to offer in its place.

Let us define a map as a conventional representation of the surface of the earth as developed on a plane surface. The geometrical, or mathematical, method of accomplishing this is known as the projection. The term 'world map' as used in this article refers to a single map which covers all, or nearly all, of the world. The so-called Mercator world map is included in this definition.

What we should really like to have is a world map that shows the component parts of the earth in their relative sizes, shapes, locations, and directions. Since it is only on a globular surface that we can fulfill all of these conditions, it is apparent that if we insist on representing the whole of the face of the earth on a plane surface, we are going to get a very distorted picture. We are not surprised that we do not obtain any great accuracy; on the contrary, we are astonished that we can attain even an approximation. It seems to be a fairly easy matter to skin a bear and make a flat rug out of his hide, but flattening a globe presents a more difficult problem.

The ingenuity of cartographers has been taxed for centuries to meet the problem of developing a projection which will come close to fulfilling the conditions previously mentioned. This can be readily accomplished on maps of small areas where the curvature of the earth is small. For large areas, however, it is only possible to satisfy approximately one or two of the requirements usually demanded and even then only at the expense of distortion in other respects.

Both the character and extent of the distortion of a map vary with the type of projection used. Both of these also vary with the size of the area covered. Unless this is kept in mind, comparisons of different projections will be decidedly unfair. We are all familiar with the classic example of distortion that is constantly raised against the

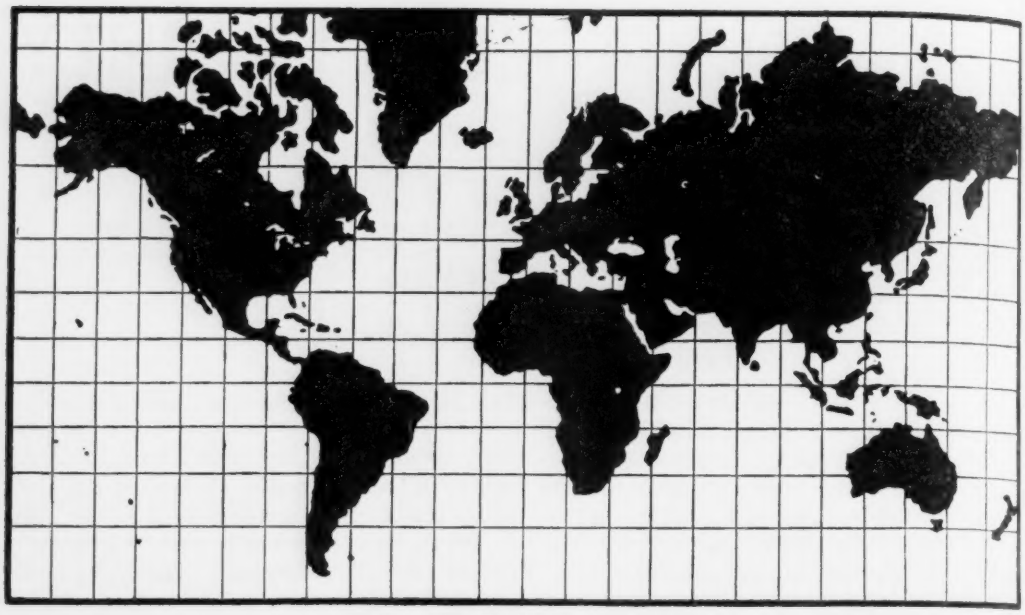


FIG. 1. MERCATOR PROJECTION

Mercator projection; namely, the disproportionate areas of Greenland and South America. On the basis of this comparison some extremists even refer to the Mercator as "falsifying" geography. And yet these same authorities recommend the use of the polar azimuthal equidistant map of the world (Fig. 2) to replace it, blandly ignoring the fact that the relative sizes of Greenland and Antarctica on this map are even more greatly disproportionate.

We can consider the various types of projections in the same way that we do a set of tools. A saw is a very handy implement but it is of little value for driving nails. Similarly we might say, for instance, that the gnomonic projection is an excellent one for laying out a great circle track but is of little value for comparing relative areas or shapes.

In selecting a projection we should therefore choose one whose characteristics best fit our purpose. For instance, if we want to compare certain areas as to the extent of cultivated land, some equal area type of projection would be best. If we require a chart for navigational purposes, we want the projection on which a compass course shows as a straight line—the Mercator. If we wish one on which we can measure accurately the bearing and distance from a single point, the azimuthal equidistant projection will be the most suitable.

There is no real substitute for a globe for the study of world-wide geography. However, globes take up a lot of space. No more than a hemisphere can be seen at once and its periphery is necessarily out of focus and distorted. In order to use a globe for world-wide coverage, it must be revolved for successive examination of areas of interest.

On the other hand, a world map does show the entire world in a single view. On a wall it takes up very little space and is always readily available. With all its technical faults it is convenient to use and for that reason world maps will remain in demand for use in schoolrooms, offices, and homes for ready reference purposes.

What kind of world map is best for general reference? The geographer or the statistician would probably stress an equal area or conformal type; the navigator would prefer the Mercator projection. They are specialists, however, whereas we are trying here to select a type of map that will find favor with the nonspecialists—the average man who knows little or nothing of projections but

who does like to enlarge his knowledge of geography occasionally by referring to a map of the world.

The interest of the general public lies, by and large, in the location of a particular place, in areas adjacent to it, and in the relative location of other places; that is, their approximate distance and direction from it. People also like to know how the mountain ranges run, the approximate altitudes of mountain peaks, the size, length, and direction of flow of rivers. They are interested in the various land, sea, and air traffic routes.

The relative sizes of different areas are, of course, of interest, as is the feature of exact shape, but great accuracy is not usually demanded. The same applies to distance. The average person rarely makes a careful measurement of distance on a world map and is usually satisfied with an approximation that is apparent to the eye.

The plotting of the shortest (great circle) distance between two points as a straight line is desirable, but this feature is impossible to obtain even approximately on world maps. Important great circle routes are often plotted as curves on maps of various types. This falls short of what is desired and is somewhat

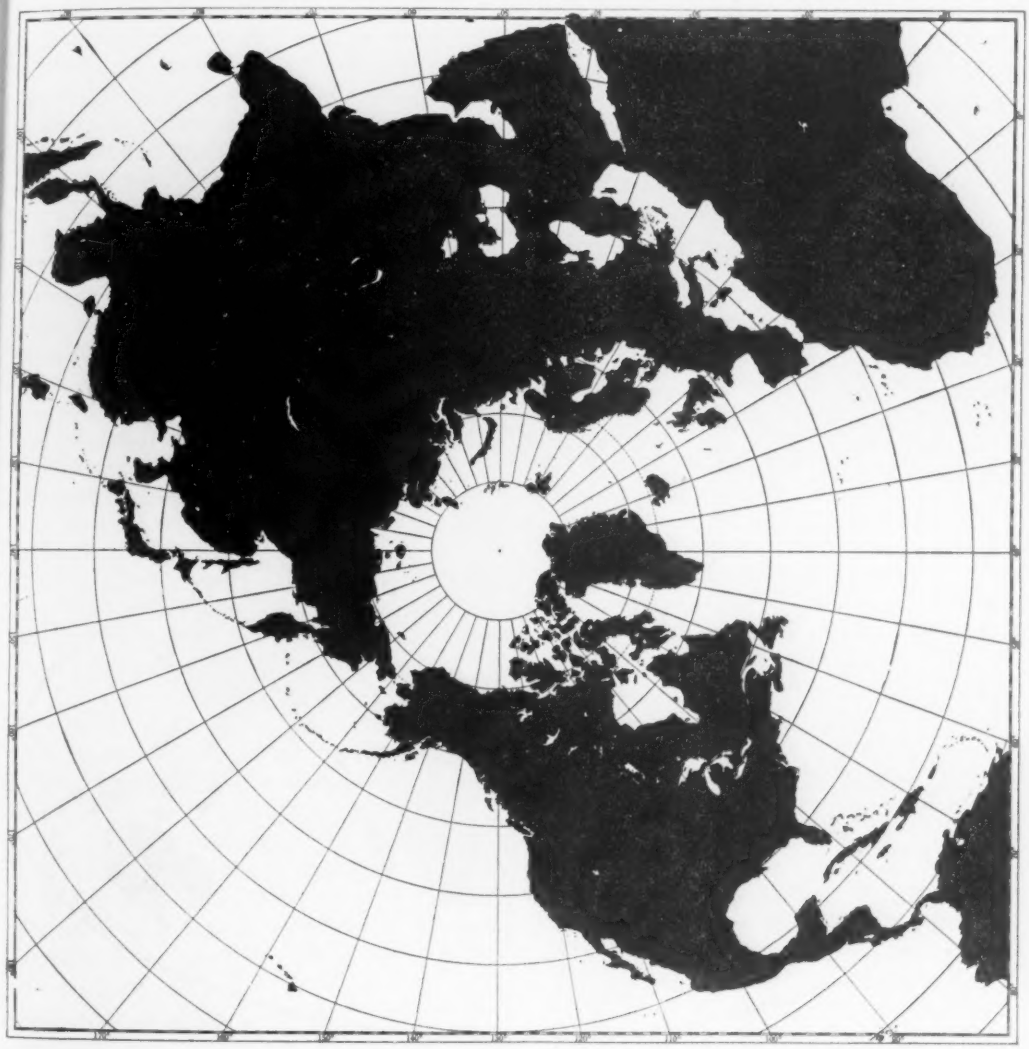


FIG. 2. POLAR AZIMUTHAL EQUIDISTANT PROJECTION

confusing to the uninitiated, but this procedure is probably the best compromise that can be made without sacrificing too much in other directions.

Continuity is another characteristic that is desired by the casual map user. Complete continuity can, of course, be obtained only on a globe. Nevertheless, we expect our maps to be such that we can follow from one place to another readily without jumping frequently across blank sections of paper. The average map reader is perplexed as to both the direction and distance between any two points when a line joining them crosses an interruption.

While the average man is not quite so exacting in his requirements as are the specialists, he still wants much more in a world map than cartographers can give him. Let us examine the principal types of projections to see how well they can fulfill his demands. Only a few types of projections actually cover the entire surface of the globe and we will start with these.

Ellipsoidal projections, such as those of Aitoff, Mollweide (Fig. 3), and Van der Grinten, give perhaps the closest approach to an equal area world map. These types cover the entire sphere. They show considerable distortion and lack of conformality and they lack continuity around the perimeter. While they give a good generalized picture of the world, they are not well adapted for showing direction, either great circle or rhumb line.

Devised within recent years are a number of types of world maps which can be folded closely around a globe and which can also be spread out flat to form a map. Cahill's butterfly map and Goode's homolographic map are samples of these and within the past year or so, Buckminster Fuller's dymaxion map and Professor Irving Fisher's icosahedral (or polygnomonic) map (Fig. 4) have been added to the list, the last one, in my opinion, being by far the best of this type.

The principal advantage of these types is that they can be folded to approximate a globe, and then by spreading them out flat the relationship between a globe and a map can be studied. For instruction purposes in the schools, these maps should be very useful. Their principal weakness when used as flat maps is their lack of continuity. Either a compass course or a great circle will change direction at the edge of each section. The bewilderment of the average man in trying to bridge the interruptions of these maps will disqualify them as popular world maps.

The other principal type of projection covering the entire world is the azimuthal equidistant projection. This type is usually seen as a polar map for which it is particularly well fitted. The United States Hydrographic

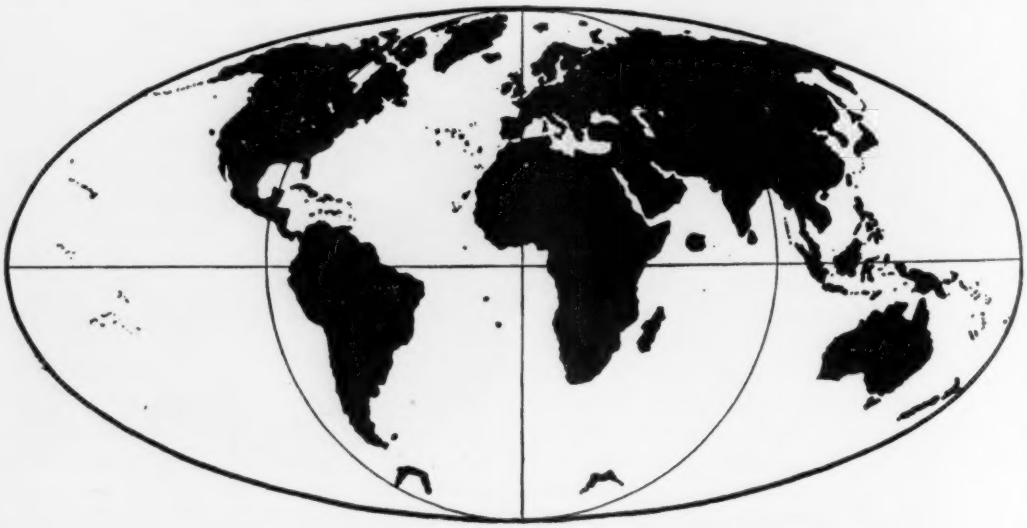
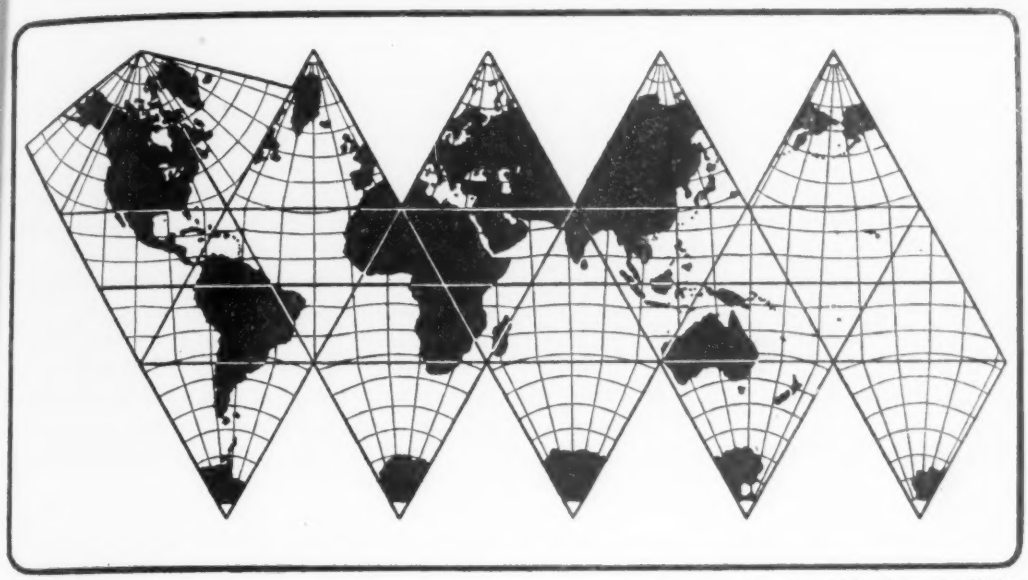


FIG. 3. MOLLWEIDE'S HOMOLOGRAPHIC PROJECTION



Courtesy of Prof. Irving Fisher

FIG. 4. FISHER'S ICOSAHEDRAL PROJECTION

Office published two world maps of this type which are centered on Washington and San Francisco respectively, but these were prepared for a special purpose and not for general use. The Hydrographic Office also uses this projection for charts of the polar regions.

This projection gives a fairly good portrayal of the earth's surface for a single hemisphere, though it is neither conformal nor equal area. The distortion and change in the distance scale are at least within reason when confined to a hemisphere, but when coverage is extended beyond this point, the distortion increases greatly until the opposite pole becomes the perimeter of the circular border.

This is the map which has been so widely publicized lately as the "Air Age" map, which is supposed to open a new era in geography and to make other types of world maps obsolete. According to some of these authors, the principal air routes of the future will lead across the vicinity of the North Pole, and this type of map will be necessary to show them correctly. Some authors have even claimed that straight lines on this map approximate great circles, although this is true only for a limited distance from the central pole.

Most of the other forms of maps that cover the entire world are variations of the preceding types, or at least they resemble them to a great extent. Most of the better-known projections, such as the polyconic, Lambert, conformal conic, and gnomonic, are not adaptable for coverage of the entire world or even approximately so.

The most popular of the so-called world maps is that on the Mercator projection. Strictly speaking, this is not a real world map because it cannot be extended to the poles. It is conformal and is continuous in an east-west direction, lacking continuity only in the polar region. Areas in the high latitudes are greatly exaggerated as compared to those in the low latitudes. It gives a fair representation of the world up to about 60 degrees latitude but beyond this, a rather distorted picture results. The distance scale varies with the latitude.

Although this projection is usually preferred for world maps by the general public, it has never been a favorite with geographers and cartographers. Some class it as the "terrible Mercator" and others even demand that it be eliminated from use in the schools. Most of this objection is based on distortion of scale in the high latitudes.

The Mercator, however, has two qualities

which make it the standard projection for navigational charts; first, the use of a rectangular system of plotting latitudes and longitudes, and second, the ability to represent a true compass course as a straight line. Of course, the straight line does not represent the shortest distance between two points, for that is a great circle track. When it appears desirable, however, to show great circles, they can be plotted as curved lines on a Mercator map and this is a rather common practice. Many Mercator world maps show these tracks between the principal commercial centers.

Although the Mercator projection was especially designed for navigational purposes, it has also proved to be the most popular type for world maps. There are two principal reasons for this. First, this map is continuous in an east-west direction. At one edge of the map we can transfer easily to the same spot on the other edge and continue on indefinitely. Of course, there is no continuity in a north-south direction. However, if the Mercator map is limited between 65 degrees north and 50 degrees south latitude, practically all the important inhabited areas of the world are included, and all the commercial routes can be seen except those passing north of Norway and Siberia.

Second, the Mercator map shows a true compass course as a straight line. Most geographers or cartographers will doubtless prefer to have a straight line represent a great circle. No map of the world, however, will show all great circles as straight lines or even approximate ones. The navigator still clings to his Mercator chart, plots his great circle track on it as a curve, and then follows this curve approximately on a series of chords of constant compass courses. Which is the more important to the layman, a straight line to represent the shortest distance or a true compass direction?

The average person knows little or nothing of great circles and rhumb lines. When he faces north and points 90 degrees to his right, he believes that if he should continue in that direction in a straight line he would be heading steadily east. If he is in New York, for instance, and points east, he feels that he is pointing towards Madrid since these two places are approximately on the same parallel of latitude. Any attempt to show him that this is not true only serves to confuse him.

If one tries to explain to him that the direction in which he points is a great circle whereas a constant easterly course will follow along a parallel of latitude, he will inquire, "Then what direction is Madrid from New York?" One can, of course, temporize by saying that it all depends on what is meant by *direction,* but probably the better answer is to say that a steady easterly course from New York will lead to Madrid, but a continually changing compass course along a great circle track will also terminate there and in a shorter time since the distance is less.

That one must follow a continually changing course to travel the shortest distance is much too complicated for the layman to appreciate, but it is quite simple to understand that one can follow a single continuous true compass course and still get there. After all, since he never expects actually to make such a trip, why should he tax his brain to understand just what it all means? But if he is told that there is one particular type of map on which a true compass course is represented by a simple straight line, he is going to prefer that type of map, and leave the cartographers and navigators to struggle with their great circle problems.

This, I believe, is one of the fundamental reasons which accounts for the popularity of the Mercator map of the world. It saves the casual map reader from having to do a little thinking. Critics may argue that this results in giving him a false impression and that he should be taught the true situation. Perhaps this should be done—particularly in the schools. However, as long as we have a general public more or less uneducated in this particular phase of the subject, there is going to be a demand for the Mercator map of the world.

Certainly no single projection is going to give us a world map which is satisfactory for all purposes, or even one that is satisfactory for general public use alone. Apparently we shall have to reach a broad compromise at best among the various qualities that are required. Each projection has some of the

desired features but lacks others, or even possesses some which are objectionable. For a straight pictorial representation, Mollweide's appears about the best, but this falls too far short in other directions. The problem of the cartographer to devise a world map on a single projection appears intractable, as one well-known authority has expressed it.

Can we solve this problem by using two separate maps? There are, of course, the "two hemisphere" types. The orthographic projection gives us two bird's-eye views of a globe, but each of the two hemispheres is badly distorted at the edges. The stereographic projection gives a fairly good map of a hemisphere (Fig. 5). Both of these projections, however, lack the continuity that we require between the two hemispheres.

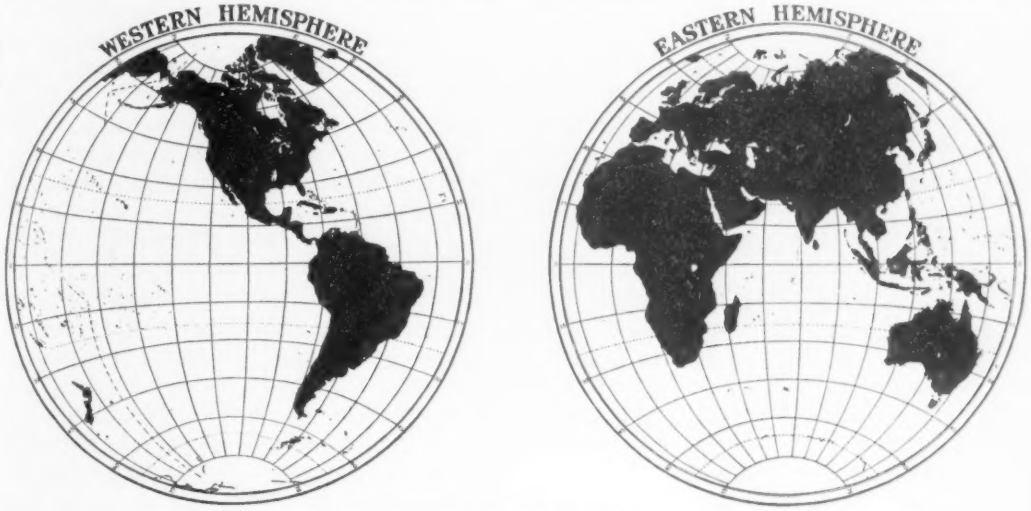


FIG. 5. STEREOGRAPHIC PROJECTION

Two polar hemispheric maps on the azimuthal equidistant projection also give slightly better coverage than the stereographic but they also lack continuity across the equatorial belt. The same can be said of any conic projection of a hemisphere. If we must have a lack of continuity, it should preferably be in those regions where we least need it; that is, around the poles.

Since the two polar hemispheric maps appear to give generally satisfactory coverage of the world except for continuity in the equatorial regions, and since the Mercator projection also is quite satisfactory except in the high latitudes, it appears that a combination of these three should supply about the best compromise that we can obtain for world-wide coverage.

The central section of this combination on the Mercator projection should extend from 72 degrees north latitude to 60 degrees south latitude. The northern limit is rather high for the Mercator projection but it is carried this far in order to take in the northern tips of Norway and Alaska. In this way, long range continuity can be obtained on one map between practically all of the inhabited areas of the globe, when this is wanted.

The two polar maps should extend from each pole to 20 degrees latitude. This would give continuous coverage over the major portions of each polar hemisphere. The azimuthal equidistant projection appears to be best suited for these polar maps. The scale for these maps should be the same as that of the Mercator map at 30 degrees latitude. Curves indicating the scale at the different latitudes should be shown on the bottom margin of the Mercator.

The combination of these three maps will give a rough visual representation of the relative sizes, shapes, distances, and directions, and of the routes over the entire world. It is not claimed that even approximate accuracy will be obtained when careful mea-

surements are wanted, but world maps are seldom used for this purpose. To the average man, a visual approximation is sufficient. The same also applies in the schoolrooms.

There remains the question as to which of the three maps should be used for our various purposes. Where they differ, which one is to be given preference? Both projections are fairly good as far as conformality is concerned. For purposes that require a comparison of equal areas, the polar chart is the better. In the equatorial belt, which is covered by the Mercator alone, comparisons may be made of areas with others on the polar map without any great exaggeration being apparent.

Distances can be measured or estimated on any of the three maps according to the scale diagrams as printed on it. Great accuracy is not usually required on world maps, nor, may I add, is it usually obtained. It should be remembered that distances measured on the Mercator represent those along a rhumb line and not along a great circle. In the equatorial belt these two lines are almost identical.

For true compass courses, the Mercator is, of course, the best. For great circles, the best solution is to have them drawn as curves on the Mercator map between the principal commercial centers of the world. In the high latitudes and across the poles, the polar chart would have to be used, and here a straight line approximates a great circle.

The polar maps suggested here were not selected to accord with the theory of the "Air Age" enthusiasts that air routes of the future will cross the bleak regions in the vicinity of the poles. A study of either a polar map or a globe will show that few, if any, air routes will extend beyond 70 degrees latitude. At least 3,000 miles of frozen waste lands or floating ice must be crossed if one flies across the poles, with no place available for landing and refueling. Surely a great saving in mileage must be evident to compensate for this handicap.

Try to pick a route in which such a saving is made. Opposite the United States and across the North Pole lie the frozen wastes of northern Siberia; opposite the thickly inhabited areas of China and Japan lies the Atlantic Ocean; and opposite Europe lies the broad expanse of the Pacific. Apparently the world was not laid out with a view to the use of polar routes. The polar maps will serve a good purpose, however, for those routes that extend into the high latitudes even if they do not go within a thousand miles of the pole. At least, these routes can be better visualized on this map than on the Mercator.

The conclusion that a combination of three maps is the best solution of a satisfactory world map was arrived at as a result of study and analysis of this subject. However, no originality is claimed for this conclusion. If the reader will consult some of the old atlases of the seventeenth century, such as those of Hondius, Jannsen, or Blaeuw, he will find the then known world similarly portrayed on the Mercator projection, with the addition of slightly smaller maps of each pole on an equidistant polar projection.

THE PROBLEM OF ORGANIC FORM*

II. COMPETITION AS AN INTEGRATIVE FORCE

By S. J. HOLMES

FROM the time of Adam Smith to the present, multitudes of writers have dwelt upon the beneficent role of competition in co-ordinating the economic and various other activities of the social organism. Along with other benefits competition obviously affords an effective spur to diversity of occupations. Where too many people are engaged in the same pursuit they seek relief from pressure by finding new employments. But the employment chosen must contribute something to the corporate life, else it would receive no reward. As a rule occupations are not followed entirely from choice, and the organization of economic life is not, or at least need not, be consciously planned. Through the supply and demand relationship it operates in a socially adaptive manner of its own accord. If there is a shortage of carpenters, the pay of carpenters increases; labor which is under the pressure of competition elsewhere flows into the partly unoccupied field and brings about a restoration of its depleted ranks. A result akin to regeneration in response to economic needs is thus brought about through the automatic operation of a sort of *vis medicatrix naturae* of the social body.

By putting a premium upon diversity of occupations, competition aids in securing the advantages accruing from the division of labor. Competition makes for diversity because, if I may speak figuratively, life is continually endeavoring to escape from it. In organized society the avenues of escape normally lead to activities requiring mutual aid and co-operation. Societies are mutual benefit associations and they tend to engender an altruism among their members that is quite closely subordinated to the egoistic interests of the group as a biological unit. One great advantage of social life is that it secures the benefits of competition and co-operation at the same time.

Can we apply the same principle to the individual organism? There is a widespread suspicion of parallels between individuals and societies. But a number of these analogies spring from the common properties of life. Both individuals and societies are composed of smaller units with the power of growth by assimilation and multiplication. In fact, increase in both cases is really the same biological process. In both cases competition must result from many of the same causes. In both cases there is a division of labor that makes for the preservation of the whole; and in both there is co-operation of component parts. It may be said also that there is competition between co-operating elements and that this circumstance would in both cases make for a balancing or automatic adjustment of activities.

The attempt to apply the concepts of competition and selective elimination to interpret the formative processes in individual organisms was first systematically undertaken by Wilhelm Roux in his brochure *Der Kampf der Teile im Organismus*. These processes exhibit many striking direct adjustments to meet departures from normality which vary from slight injuries to the loss of entire organs. Since contingencies never before encountered in the history of the race are continually met by appropriate adjustments, it was contended that they could not have been provided for in all details by natural selection. How can such apparently purposive behavior be explained? Being a mechanistic biologist strongly opposed to the theories of vitalists, teleologists, *et hoc genus omne*, Roux bethought himself of a way of meeting the difficulty by extending the principle of selection to the component parts of the organism. Roux held that the parts of an organism are engaged in a struggle ranging from organs, through tissues and cells, down to the ultimate self-perpetuating units of which, in common with numerous biolo-

* Continued from p. 232 of the preceeding issue.

gists of his day, he conceived living matter to be built up. Since these living units were supposed to grow and multiply, they would inevitably compete, and those variations among them which are better fitted than others to cope with the particular conditions that affect them would gain the upper hand and bring about a better adjustment to their environment. Roux laid great stress on the application of his theory to explain functional hypertrophy and atrophy, and he advanced much evidence to show that these processes play an important role especially in the functional period of development.

That struggle occurs between cells would seem to be a reasonable deduction from the fact that they are more or less individualized units with the power of growth and multiplication. In a starving planarian or Hydra, which may become reduced to a small fraction of its original size, there is an enormous elimination of cells along with the maintenance of an approximately proportional representation of the various organs and tissues. Under these conditions a lively intercellular struggle would seem to be inevitable.

That the struggle of its parts suffices to give a satisfactory general explanation of the direct adaptations of the organism is, however, open to serious question. We may take as an illustration a phenomenon by which Roux was strongly impressed and which seemed to him to be entirely inexplicable by the ordinary Darwinian theory. The lamellae of bone are so disposed as to provide the maximum resistance to the stresses and strains to which they are exposed. Where bones are broken and grow together in an abnormal position, the lamellae are directed so as to meet the new demands. Such cases, it was urged, cannot possibly be explained by the elimination of individuals among the ancestry. The adaptation is direct and not specifically provided for by heredity. A similar reaction is given by connective tissue which lays down fibers in the direction of greatest tension. It is shown experimentally that connective tissue subjected to new strains responds directly by developing fibers which resist the strain. Roux attributes these reactions to functional stimulation which causes a specific kind of hypertrophy. But he goes further and attempts to account for this kind of functional hypertrophy as a consequence of the struggle of the parts of the cells involved. Somehow, he thinks, those units prevail that react so as to meet the situation. But in these direct reactions of connective tissue and its derivatives we are dealing with a general mode of reaction, the production of fibers or lamellae in the direction of strain. Given this general mode of reaction to strain, the cells could make adaptive reactions to many varied and unusual contingencies.

In these adaptations there is reason to believe that the apparently teleological behavior is a direct consequence of the physical and mechanical properties of proteins quite independent of any supposed struggle of their postulated units. There are fibers formed in gels and their arrangement may be determined by stretching. It is significant that collagen, which is a protein occurring abundantly in connective tissue, responds to a pull by arranging its fibers in a way that might be regarded as a direct adaptation.

That organs increase through use and diminish through disuse may be susceptible of a purely physiological explanation without involving any internecine warfare among the vital units. Owing to this relation to functional stimuli, parts of the organism may within limits adjust themselves to the requirements of the organism as a whole. Roux's adherence to the doctrine that living protoplasm is made up of minute units intermediate between molecules and cells often led him to assume the existence of selective survival where there is little evidence that such process really goes on. As matters work out in the living body, struggle commonly leads to balanced activity instead of elimination. But as to how the organism solves this problem Roux is far from clear. The organic mechanism as he conceived it lacks a balance wheel.

Very often the struggle for existence is merely destructive. In an aggregate of independent units it commonly leads to homogeneity through the extinction of everything except the strongest. But within an organized society or an individual it may work out in an entirely different way. And why? This is because the parts of a society and of an individual organism stand in a relation

of mutual dependence. Where a part receives from others materials or stimuli required for its life, it cannot increase to the extent of injuring other parts without automatically incurring an injury to itself. Each part of a living aggregate has a primary tendency to extend itself and compete with others. It is this tendency which at least in part leads it to increase its activities when they fall below the rate required for supplying the other parts. This egoistic self-seeking is thus an indispensable factor in securing a balancing of functions. The checks elicited when this functioning or growth exceeds certain bounds are equally indispensable. Between the two an organism, individual or social, tends to settle into a state of moving equilibrium. *The process of expansion which leads to competition thus works as an integrative force when it takes place between mutually dependent parts.*

In this simple fact we have a principle of fundamental importance in relation to the regulation of organic form and function. Under these conditions Roux's conception of the struggle of parts leading to the elimination of this or that variant kind of unit, whether living molecules or cells, would have a relatively limited sphere of application. Most struggle among the parts of an organism, as among the individuals within a society, stops short of the lethal stage.

Two of the basic problems that confront one who attempts the formidable task of analyzing development are (1) the problem of divergent differentiation and (2) the problem of the proper arrangement of parts. It is obvious that the formation of a lot of differentiated cells and tissues could never produce a viable organism unless these parts were arranged in a very special manner. How do they come to occupy the right places at the right times? Weismann's attempt to explain divergence and proper placement as a consequence of qualitative nuclear division got him into all sorts of trouble and since it is now completely rejected, it requires no further comment. Nor need we linger over the germinal area theory of His and his appeal to undulations to account for the initial germinal map. The crystal analogies are too vague and general to be of much assistance, and the theories of gradients and of formative fields are in much the same boat. Personally, I am convinced that if we ever arrive at an adequate interpretation of morphogenic processes it will be through a study of the functional relationships of the parts of a developing or regenerating organism.

If we regard differentiation as a consequence of continued balancing, our two basic problems of divergence and proper placement are not two but one. We must assume that as a rule it is placement that causes divergence, and that divergence results from evocation in response to a localized situation. The stimulus complex varies with the local area, and out of the many possibilities of reaction afforded by its many genes a cell reacts differently in different regions of the developing egg. To the question as to why the response is a fitting one adjusted to the needs of the whole, one may say that it is a consequence of forces analogous to those by which socially valuable adjustments are unconsciously made in the social organism. These flow from the supply and demand relationship in which competition enters as a component factor.

In the course of evolution the kind of variations that dependent parts would tend to accumulate would be those which check the activities of associated parts when these exceed a certain norm of intensity. The role of inhibition in co-ordinating the functions of the adult body is generally familiar. It is manifested in the regulation of the heart beat, the secretion of many glands, and the co-ordination of many functions carried out by several organs. There are substances given off by certain organs which are definitely inhibitory in their action on other parts, and the integration of the adult body is dependent upon their influence. If some organs receive accelerator and inhibitory nerves which give off their different chemical stimuli, it is not unreasonable to suppose that various parts in the early embryo receive both accelerator and inhibitory substances from their near neighbors, and that these act as automatic balancers of functioning and formative activities.

Most vital activity consists of responses to the organism's own stimuli. That these responses should effect the development of a complex and harmoniously functioning whole

is possible only if the process starts with a bit of living matter having potencies for making many kinds of adaptive reactions and that these change from stage to stage. This credits our bit of living matter with stupendous, almost miraculous, powers. But so long as they are not quite miraculous, like entelechies, this is nothing against the supposition. The bit of living matter does almost miraculous things. Hence any theory of development seems almost staggering when we try to imagine its operation in detail. If we conceive the complexities of development with all the regulation it involves as flowing inevitably from the constitution of the fertilized ovum, we have brought the problem of the teleology of the individual to the constitution of the germ plasm and thereby handed it over to the phylogenist. If the phylogenist is an orthodox Darwinian, he would account for the evolution of the germ plasm through the slow accumulation of favorable variations of developmental responsiveness. Roux and other students of direct adaptation were greatly troubled over what they deemed the inadequacy of the phylogenetic explanation of new and often resourceful means that organisms employ to attain normal wholeness. They felt compelled to seek some other way of explaining teleological behavior. But the situation was really not so bad as they imagined. Natural selection does not endow the organism directly with this or that structure, but with ways of making morphogenic responses to stimuli. The structures produced are incidental upon the reaction modes of the species. Hence many new adaptive modifications in the arrangement of connective tissue fibers, bone lamellae, and other striking exhibitions of purposive behavior are as explicable in terms of selection as is tough hide or protective coloration.

But, as we have contended, there is a justification for Roux's conception of the struggle of the parts in ontogeny. He did not conceive of it as a struggle between mutually dependent parts, although like all other biologists he talked about this interdependence. He did not combine the ideas of struggle and dependence in a way that would throw light on the organism's capacity for self-regulation or point out that, while struggle between independent parts would lead to homogeneity in this or that cell and would probably wreck the whole organism, the struggle between parts that are mutually dependent makes for an automatic self-regulation of functions. The numerous reaction modes which I have mentioned as having been picked up during the long course of evolution have been to a large extent responses that secured the advantages of better cellular and organismal co-operation. The genes have had a long discipline through selection for the various parts they play in the drama of embryonic development. Directly or indirectly they set up processes which tend to go on increasing and hence sooner or later interfere with one another's expansion, but during their evolutionary history they have become dependent while securing the advantages of essentially social relationships. Through these relationships, like the members of a society, they automatically regulate their affairs.

III. THE PROBLEM OF DIVERGENT DIFFERENTIATION

One of the most conspicuous features of embryonic development is that cells originally very much alike become transformed into nerve, muscle, gland, and other kinds of cells of the most dissimilar form and function, and that they produce very different chemical substances of which not the least trace can be found in their simpler progenitors. We commonly try to explain differences as consequences of previous differences and carry the process back as far as we can go. We might conceive of an egg whose cytoplasm is devoid of all regional diversity. Some inequality of environmental influence might set up a primary polarity and something else might determine the plane of bilateral symmetry. Surface tension may cause the outer protoplasm to as-

sume properties different from those of the interior, and metabolic products which are immiscible may segregate like oil and vinegar in French dressing. Visible differences are often brought about in early development through the flow of materials. In the frog's egg the inward migration of peripheral pigment causes the formation of the gray crescent commonly opposite the entrance point of the spermatozoon. The egg of *Styela* shows an extensive streaming of both clear and yellow cytoplasm to their definitive positions. During the early development of many eggs, materials become more sharply separated out. One may say that these eggs become more or less unscrambled preparatory to undergoing further development.

Embryonic development, however, can be accounted for only in small part by initial polarity, surface tension, and other factors to which we have referred. Aside from these factors there must be some very potent force compelling chemical processes to run in different directions in various regions of the developing egg, so that, out of a relatively homogenous chemical matrix, we finally get a highly diversified aggregate of chemical factories. Why this great urge to chemical diversification?

The phenomenon is the more remarkable because it would seem that the natural tendency of chemical activity would be toward uniformity instead of diversity. In any fluid medium the prevalent tendency toward chemical equilibrium would be to overcome divergence. Differences of composition, once established, might be maintained by semipermeable membranes. But, however numerous may be the compartments so separated, the tendency of the system would be to settle into a static condition as uniform throughout as the walls of the compartments would permit. Vitalists have often urged that chemical forces alone would effect the dissolution of living matter, and that their influence is overcome only through the constructive vital activities of the organism. Life has been looked upon as an upbuilding force, like Vishnu, the Preserver, continually at war with Siva, the Destroyer. But, as Claude Bernard has pointed out, the co-operation of Siva is quite as necessary as that of Vishnu in the process of living. And now, since the discovery of the synthetic function of enzymes, Vishnu and Siva have turned out to be the same person.

An aid to the maintenance of chemical diversification is afforded by the fact that the semipermeable membranes of living protoplasm have selective and variable permeabilities by which they function in a manner different from the membranes of most nonliving materials. An individual egg is a mass of protoplasm, partly gel and partly sol, with numerous interstices within the framework of more nearly solidified jelly. The nucleus contains many varieties of genes which produce many kinds of enzyme action, both synthetic and destructive. The more fluid part of the protoplasm contains salts, dissolved carbohydrates, proteins, lecithin, fats, hormones, vitamins, and various other chemicals. Throughout the cytoplasm are many little chemical factories in which changes go on, resulting in oxidation, secretion, fermentation, and other processes the products of which may be selectively transuded to other cells or to the outside of the organism. The gelled protoplasm constitutes a sort of framework within the interstices of which the metabolism going on in the more fluid contents supplies the energy for living. But the gelled skeleton may participate in metabolic changes taking place in the fluids by which it is bathed. Through its adsorptive and enzyme functions it may not only act like a platinum sponge in effecting chemical changes in materials within it, but syntheses may be effected through which its own peculiar substance may grow. If through catalytic action different substances are built up in different parts of a cell, they may not diffuse uniformly throughout the mass for two reasons: (1) Complex molecules may be prevented from diffusion by the semipermeability of the surrounding gels, and (2) after their formation they may be united to the more or less gelled structure of the living tissue. They do not diffuse until they are uniformly distributed, simply because they are anchored as soon as formed.

In constructive chemical processes a very important role is played by the labile state of so-called living protoplasm, much of which

is close to the line between a gel and a sol. A fluid condition is eminently favorable for chemical action, while a more or less solid state is essential for the perservation of structural differentiation. Almost no chemical action goes on in a dried seed or a desiccated tardigrade, but when water soaks in and the tissues swell, numerous little chemical factories appear in the various cells and vacuoles of the organism, which is thus brought to life. Some organisms survive the almost complete absence of fluid, and others withstand the almost complete loss of solidified structures. The cytoplasm of some infusorians assumes a complexity and regularity of organization which rivals that of many multicellular animals. Nevertheless, in a number of species it is just *pro tem* construction. In these forms not only does a good deal of differentiation disappear during fission, but in the encystment stage it is almost completely resorbed and little else remains visible except the cyst wall, the nucleus, and the semifluid, almost homogeneous contents.

An intimate association of sol and gel affords a condition for the maintenance of different kinds of metabolic processes against the influences making for uniformity of chemical composition. Chemical differentiation occurs in spite of a seeming opposition of counteracting influences. The material basis for differentiation along diverging lines we may assume to be the possession of a variety of self-perpetuating genes, which by the kinds of enzyme action they exert are able to cause the different morphogenic changes involved in histogenesis. Each of these early cells has a varied repertoire, and the stimuli to which they are attuned to respond are furnished largely by their immediate environment.

The idea that differentiation rests largely upon gene action has been ably developed by Goldschmidt in his *Physiologische Theorie der Vererbung*. The genes are regarded as catalyzers (directly or indirectly) of various chemical processes, the products of the activities of one gene serving as the basis for the action of other genes which would otherwise lie latent. Through interactions between genes and cytoplasm a regular sequence of products would be formed in an epigenetic fashion based upon the preformed complex of the genes. With this basic feature of Goldschmidt's theory the views here set forth are, I believe, in entire accord. Other suggestive ideas in the volume referred to cannot be adequately discussed in the present connection.

Divergent differentiation we have looked upon as in the main the effect of morphogenic responses elicited through the equilibrating activities of the organism. Through the selection of gene mutations during the course of evolution we may suppose that embryonic cells have been endowed with their varied powers of producing morphoses on the physical and chemical level. Through enzyme action set up by genes we have a variety of proteins and other chemical substances which build up structures in the form of fibrils, lattices, and other elements commonly observed in different types of cells. Since many of the synthesized substances are capable of catalyzing other reactions in turn, and since the kinds of syntheses going on are influenced by other physical factors, we may have within the cell a variety of protein and other configurations produced in different parts. The part of a mesothelial cell adjoining a substratum often reacts by the formation of fibers, whereas the free surface may become thickened. The formation of fibers may take place in nonliving plasma in ways so closely similar to their formation within the cell that in many cases it is often difficult to decide upon their real place of origin. Polarity is often induced through the influence of contact stimuli, as is exemplified by epithelium in tissue cultures. These physicochemical morphoses are dependent upon genes and natural selection has chosen them on the basis of their ability to get along together. The way in which any aggregate develops, whether of genes or individuals in society, depends upon the selection of its members. The apparent goal-seeking which is often exhibited in such striking ways in ontogeny and other formative processes is not something primary. Ontogeny may be compared to a piece of music in which notes and chords follow in a very definite order from beginning to end.

The piece is learned only after many rehearsals in which all discords and false notes are thrown out. Or, to change the figure, we may say that Nature fills the nuclei of the germ cells with genes and then sees what kind of products result. The genes may produce a monstrosity, a weakling, or a highly successful organism. A point I would especially emphasize is that Nature has stocked the germ cells with genes which make for the interdependence of developing parts. She has made the parts in ways that aid in the development of other parts. If natural selection is capable of operating at all, there is no reason to doubt that it is quite within its competence to fit out the beginning individual with a collection of genes which would react to the organic environment by the formation of mutually dependent parts, each of which tends to grow on its own account, but whose undue growth or functioning would be checked through the reactions elicited from its associated organs. In this way an organism could become a self-regulating mechanism. It would have the capacity for making a number of direct adaptations, of correcting deviations from the normal, and of reacting in many ways that appear to be guided by the effort to achieve an end. Co-operation as a device for individual self-realization is a principle discovered in the course of evolution long before the advent of social groups. Parts of the organism become as much advantaged by it and dependent upon it as are babies in a human society.

Coming back to our question as to why the parts of a developing egg *tend* to diverge, one must say that there is no *primary* bent thereto, but that divergence is mainly a consequence of evocation, as in societies of human beings, and that it is closely tied up with the advantages of co-operation and division of labor. In other words, development is a kind of mutual evocatory process in which parts have been formed to react to certain organic situations, much as many animals are fitted with a number of specific instincts. From this viewpoint an organism in its development, regeneration, physiological functioning, and behavior is performing similarly in making responses to particular conditions, internal and external.

I have already called attention to the role of competition in the integration of life processes. This force may work destructively as well as constructively, but from the standpoint of the individual organism Nature has managed to keep it well employed by the way she has selected the genes. She has done this through the simple device of making competing parts interdependent. But along with this there has gone the development of checks to activity, especially exemplified by the formation of specific inhibitory substances which counteract the undue functioning of particular organs. Integration, which is achieved by an elaborate system of checks and balances, as in the social body, requires very different degrees of organization in different forms. Where there is a multitude of different kinds of genes, each endeavoring to have a finger in the pie at some period or other (else why should they be there?), the integration of all their activities could hardly occur other than in a complex organism.

The reasons for the repeated divergences of ontogeny are therefore to be sought largely in the complex of genes. The reasons for the seemingly teleological direction of formative processes are to be looked for in the same place. The germ plasm has been made thus and so through its phylogenic history, and it develops thus and so because its variations have been selected to react in a particular fashion. To the question why the organism mends its injuries, cures its ills, adjusts itself to new conditions, and exhibits so many adaptive responses to emergencies, or, in other words, behaves as if it were animated by a purposive striving after normal wholeness, the mechanists can only answer that it is able to do these things by virtue of its automatic functional balancing, which it owes to its genic construction. The apparently novel adjustments of the individual are after all a heritage of its past.

We are prone to look upon natural selection as working with finished products. Its chief concern, however, is with experiments in ontogeny. Organisms perish not only because they fail to respond properly to their environment, but because there is maladjustment in the internal machinery. A variant

internal stimulus may lead to death, or a stimulus may not be responded to in the proper manner. In either case there is lack of adjustment in the stimulus-response mechanism. Once sufficiently diverted from their usual course, formative processes may go on building ever further deviations and finally give rise to monstrosities, teratomas, and other anomalous products. All these realized ends of endeavor exhibit a marvelous amount of internal adaptation in their vascular supply, the disposition of their individual tissue, and in other ways that might well excite the admiration of a Paley for their adjustment of means to ends. We may call these products abnormal, but the abortive mouse embryos homozygous for dominant yellow are in one sense just as normal productions as their well-developed litter mates. The litter mates arrive at different goals, but each is a logical consequence of its complex of genes.

Despite many contentions to the contrary, ontogeny per se involves no striving toward a living or self-perpetuating goal. It may be quite as much a striving to produce an amorphous heap of cells as a viable organism. What it effects depends upon its outfit of genes. It owes the adaptiveness of its goal to its phylogenic history. Fitted out with a proper genome, it may attain its goal by varied and seemingly ingenious methods which may appear to necessitate an appeal to a vitalistic principle. There is nothing in the mere change from the simple to the complex that needs especially to excite our wonder. The striking feature for formative processes that has proved so puzzling is their resourcefulness in attaining their apparent goals amid circumstances which throw them off the usual track and lead them to adopt different methods of procedure to reach normal wholeness. But this seemingly end-seeking behavior has its ground in the forces that have guided the selective preservation of mutant genes.

(To be concluded)

THINGS ETERNAL

What seems more stable than some mighty mountain range?
And what more frail than wing of butterfly?
Yet mountain ranges rise and wear away
Through eon after eon of unending change.

While patterns of the insect wing, unchanging
In the species, though each butterfly must die,
Persist through countless generations,
Outlasting, in the end, the very granite hills.

Such constancy, in fragile organism—
Its physiology in equilibrium
With all the forces of environment,
Through geologic time—is worth our awe
Like constellation spangled skies at night,
Or like the Andes rising from Pampean plain.

—Karl P. Schmidt

SCIENCE IN FRENCH CANADA*

II. SCIENTIFIC ENDEAVOR

By PIERRE DANSEREAU

It is hardly possible in a few pages to trace the whole history of science in French Canada. In the first place, such a history has never been written. At best only an outline can be given of the evolution of scientific thought and methods, and a brief description supplied of original achievements and contributions.

Preinstitutional period. Among the French colonists who came to this country before 1763, many were well-educated men, as Peter Kalm remarked,[3] and with a frame of mind which led them to speculate on what they saw, and in some cases to express their observations in their reports, diaries or *relations*, sometimes in surprisingly incisive form. The great discoverers themselves, Cartier and Champlain, for instance, have given us accounts of their experiences which are considered valuable by science today.[4,5] Men like Louis Hébert[6] and Michel Sarrazin[7] were scientists in the exact sense of the term. The latter kept up a correspondence with Tournefort at the *Jardin du Roy* in Paris. In his honor that extraordinary North American freak, the pitcher-plant, was named *Sarracenia purpurea*.[8] Many interesting observations are also to be found in Pierre Boucher de Boucherville's book (1664) entitled *Histoire véritable et naturelle de la Nouvelle-France*. Also, Charlevoix, Sagard, the Jesuits, and other historians and chroniclers have given us fragments of the natural history of our country.

But all this does not amount to a true scientific movement, does not create an atmosphere, even less a tradition. In fact, the early part of the nineteenth century was quite unproductive. It was not until the 1860's that notable scientific activity was initiated. In 1868 *le Naturaliste Canadien*, a periodical still in existence, was first issued by Abbé Léon Provancher, who also published an entomological fauna[9] and the first flora[10] of Canada.

Abbé Provancher, Abbé Brunet, Monseignor Laflamme, and others were pioneers in Canadian science. Today their modest essays do not appear very important; no doubt their greatest contribution was to create an atmosphere favorable to the founding of scientific institutions of lasting value. In an overwhelmingly scholastic milieu, theirs was a difficult task to induce the proper and indispensable respect for science.

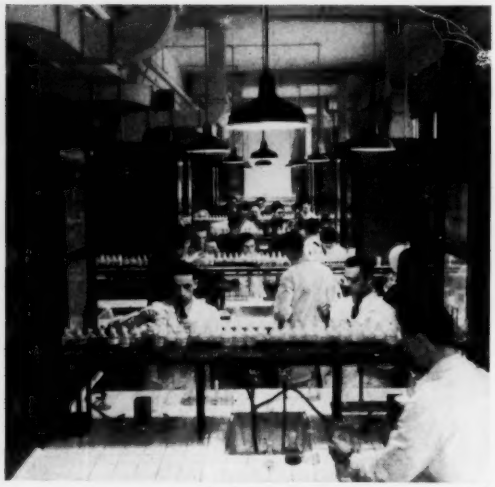
Institutions. A nation's cultural activities may be best reflected by the character of its institutions, although that is not the only criterion. Surely universities and schools of higher learning are at once the depositories and the authorized interpreters of that nation's most valued intellectual traditions. So it is in French Canada, where, from the first, the seminaries took the lead and gave rise to the universities, which, in turn, promoted other institutions.

The *Séminaire de Québec* was founded in 1663 and became in part Université Laval in 1852. Its history is not without analogy with that of some of the more illustrious American institutions, such as Harvard University (Harvard College from 1636 until 1780). The *Ecole de Médecine* in Montreal (later the Faculty of Medicine of the *Université de Montréal*) was founded in 1843. The *Université d'Ottawa* was founded in 1848 and that of Saint-Joseph, New-Brunswick, in 1864. *Université de Montréal* originated in 1878. The professional schools of engineering (1873), agronomy (1893), commerce (1907), forestry (1907), and mining (1938) were opened later and duly affiliated with either the *Université Laval* or the *Université de Montréal*.

Today, these institutions are flourishing and have many thousands of students. *Université de Montréal* has 950 professors and

* Continued from p. 194 of the preceding issue.

[3] Superscript numbers refer to "Literature Cited" at the end of this article.



André de Tonnancour, Montreal
CHEMICAL LABORATORY, MONTRÉAL

over 7000 students (50 and 413 in the *Faculté des Sciences*); *Université Laval* has 355 professors and about 2000 students (86 professors and 302 students in science, and 71 and 117 in the Graduate Faculty). As for *Université d'Ottawa* (with 187 professors and 2000 students) and *Université Saint-Joseph* (with 45 professors and 430 students), they are not universities in the full sense, but colleges.

It may not be unnecessary to remark at this point that all courses in these universities are given in French. Their role in keeping French culture alive in Canada is outstanding, for the French Canadian's language is a very living thing. It differs only slightly, if at all, from the language spoken in France; not quite as much, perhaps, as American does from English. The French Canadian's language may be a little provincial and archaic; it is, however, no mere sentimental symbol of past allegiance, but a living instrument for the expression of all phases of his personality.

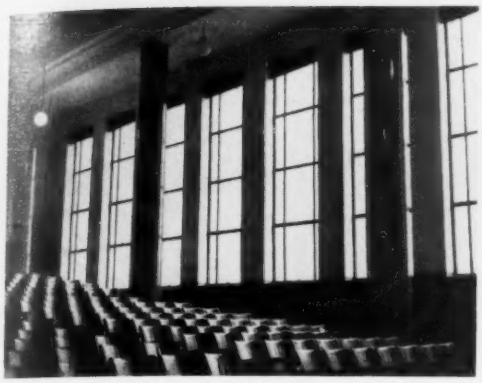
The relative isolation entailed by it has more than once put him to a disadvantage, notably in the realm of science. His is a constant problem of adaptation. The nineteenth century has been very difficult, because it did not appear any too clearly that he could manage to put up the institutions of higher learning indispensable to the survival of a culture he cherished. If French Canada's individuality was safeguarded a first time in the early nineteenth century by aloofness, it could not be saved again by that means in this mechanical age.

The game, however, has been played and won, or so it seems today. Montreal and Quebec have universities of good standing which can prepare men to stand on both feet on the international scene. The native intelligence and resources of the French-Canadian can now be developed to the full in his own country. The battle of tomorrow, so far as he is concerned, is no longer direct physical, economic, or cultural adaptation to this North American environment. The next test in the struggle for survival of French Canada—as of most small nations no doubt—will be the faculty to produce men of outstanding ability, capable of influencing to some degree international thought; political, artistic, scientific, or all three.

Just how well equipped is this group of four million North Americans to put forth creations capable of influencing somewhat the course of humanity's progress? This would seem a grandiose way of putting it to some French-Canadians, for not many have such lofty ambitions. It may be that all too few realize that the problem really lies there, and no doubt the period immediately following this war will appear to justify the minders-of-their-own-business and other pessimists.

But if French Canada is not just a little ahead, intellectually, of some of its more powerful allies, it runs a very real danger of sinking into insignificance. There is reason to hope, however, that its heritage has prepared it for the rather tremendous intellectual effort which will give it some measure of leadership. Switzerland, Sweden, Denmark have done something of that sort in Europe in the first half of this century.

Surely for the sociologist, the ethnographer, the anthropologist, it is well worth while to look into the destiny of this small people. Their history presents a clear-cut pattern. Their intentions are quite simple too. A precise ecological study of their adaptation to the ruddy Laurentian landscape would well repay the investigator's effort.[11] The incipient stages of a new French culture should matter to America. Whether there be any future in it can best



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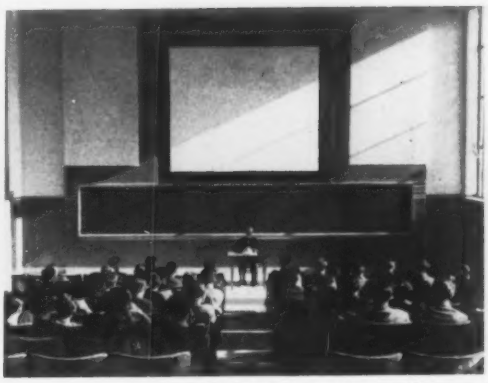
LARGE LECTURE HALL, MONTRÉAL



André de Tonnancour, Montreal
ANOTHER VIEW OF THE SAME HALL

be judged by the quality of that culture, by its trueness to the fundamentals of civilization itself. And that is to be measured not by numbers, but by spirit.

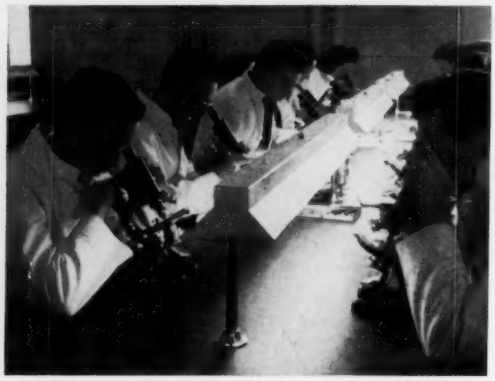
The philosophical trend. Even more significant, therefore, than the above-described institutions is the spirit behind their evolution, outwardly so similar to American and Anglo-Canadian institutions.

It may appear at first that the total number of postgraduate students is small. Here is the very judicious explanation by an Anglo-Canadian professor of physics[12] on the subject:

> The insistence in these universities on (i) a broad training in the humanities before specialization in science, (ii) the thorough mastery of two or more languages and, (iii) special attention to subjects considered to be of value in cultural development and character formation, is in part responsible for the postponement of advanced work in physics by their students to periods of graduate training at other universities.
>
> The quality of the general education and the distributed culture of the better French students, which arises from this policy, often puts to shame their English-speaking friends of similar age. The latter have frequently confined their attention too soon and too exclusively to specific subjects or to specific professional training. It would appear that Canadian physicists in general have too often neglected important ingredients in education, and should possibly take steps to defer the specialization of a student until a proper standard of general education has been attained. On the other hand, it must be realized that university standards in physics cannot be obtained without an exceptionally intense training, in an atmosphere in which the active advance of knowledge exerts an unceasing influence. Adequate mastery of mathematics and the methods of scientific thought and procedure are rarely ever obtained by a student who has devoted the golden years of his teens more to the cultivation of memory than of reason, and more to following than to exploring and applying.

This last paragraph emphasizes the delicate balance which an ideal system of education should seek between information, specialization, and actual knowledge of separate and demonstrable facts on the one hand, and culture and the power to reason, on the other. No doubt our French-Canadian system will appear to many to stress synthesis with too few facts, too little analysis; while to others it will seem that the current American and Anglo-Canadian system affords too little correlation between otherwise well apprehended facts. This problem is foremost in the minds of many teachers. It would seem that several American educators feel rather strongly on this point and urge a reaction against the excesses of vocational training in the universities. Among others, the president of the University of Chicago has quite forcibly expressed this point of view: it seems to him that premature specialization is responsible for the narrowly limited intellectual horizon of many otherwise intelligent and progressive Americans.[13]

I also had occasion only recently to hear several discussions in Middle Western institutions of the "liberal arts" and their place in education. It was often agreed that the student's capacity for earning a living far outran his participation in that accumulated "wealth of nations" past and present, known as culture.[14] A new type of school has recently originated at Annapolis, Maryland, in response to this feeling. Specialization is



André de Tonnancour, Montreal
MEDICAL LABORATORY, MONTRÉAL

resolutely abandoned, direct access to the classics is stressed.[15] The St. John's experiment is not without analogy with the French-Canadian *cours classique.*

On the other hand, French Canadians are well aware—because they have paid the price—of the inconveniences of a too speculative education. This has been the main cause of their failure to control their own commerce and industry and of their relative backwardness in creative science. However, they are generally agreed that the "classical" system may be in need of modification but it must not be abandoned. In the words of the present Minister of Education of the Province of Quebec, the Honorable Hector Perrier, addressing the *Canada and Newfoundland Education Association* and referring to Quebec's differences with the other provinces: "We must seek the solution of our educational problems not in uniformity of programmes and systems, but in an open-minded collaboration and a healthy emulation with the other provinces."

The basis of French-Canadian education therefore remains unchanged; it is humanistic and can only become more so by an intelligent and more comprehensive integration and diffusion of contemporary science. It can very well be argued, in fact, that a humanistic background provides the best setting for scientific work. Only recently Whittaker[16] pointed out that "of all types of philosophy, the Aristotelian-Scholastic is, in its principles, the most congenial to the scientific mind." To the French-Canadian educator, scientific facts and theories have little pedagogic value until they can be so integrated. Surely this attitude is intellectually no more dangerous than its opposite, which consists in a purely utilitarian conception of science. Economically and socially, of course, it can be disadvantageous. French Canadians do not fail to see this point. But they apparently care more for their traditions and way of life than for economic advancement.

It is no doubt well, and assuredly logical, that scientific progress in French Canada has not taken place too suddenly. It could then scarcely have failed to have been imitative to a degree hardly compatible with authentic personal expression. There is no need to discuss here the principle of French-Canadian culture as a whole, of its distinctness and relative isolation. It may be that Canadians would be better off if they all spoke the same language and all that. But the fact is that they do not, and apparently they have every intention of maintaining the *status quo* in cultural matters at least. Let us take this for granted and proceed to appreciate the modalities of this culture as it stands.

Educational practice. The educational pattern of French Canada is very much as follows: After about six or seven years of primary school, a child is sent either to the classical college or to a primary superior school. The latter offers six or seven years of study which do not lead to a bachelor of arts degree but allow entry (usually following a special examination) to some of the Faculties. The classical college has four years of "high school" and four years of "university course": *belles-lettres* (freshman), *rhétorique* (sophomore), *philosophie I* (junior) and *philosophie II* (senior). The university then grants the degree of Bachelor of Arts (B.A.). These studies are not exactly equivalent to either high school or college of the American system, as will be obvious from further description of the curriculum.

The *cours classique* is not carried on in the university proper but is conducted in twenty-three classical colleges affiliated with the *Universitê de Montréal* and almost as many with *Université Laval* of Québec. The directors of these colleges, together with rep-

resentatives of the University, constitute a Faculty of Arts—extramural, so to speak. It is this body which legislates on the programs to be carried out, more or less uniformly, in the colleges. Each college maintains some measure of autonomy. I can see no cause for alarm on this score since it is likely to, and in fact does, stimulate emulation, and also since it makes for diversity and the establishment of separate standards of excellence.

The *cours classique* does not afford options of any kind. The general curriculum, comprising both literary and scientific subjects, is followed by all. It has been pointed out above that the science program of these institutions, until quite recently, left much to be desired. In many of them nowadays a satisfactory balance is being reached between the two major interests. No specialized training, or very little, is offered because it is generally felt that before the student can accurately and wisely choose, he must have learned enough of each subject to understand its significance and to test his own aptitudes. It is unthinkable to educators in French Canada that any student be allowed to "skip" any subject altogether.

The student then comes to the university or to one of its affiliated professional schools. He can study: theology (Catholic), law, medicine, philosophy, letters, science, dentistry, pharmacy, social sciences, which are represented by as many faculties; or engineering, agriculture, veterinary medicine, commerce, optometry, forestry, mining, electricity, taught in affiliated faculties.

Now to consider the Faculty of Sciences which concerns us more immediately: To anyone familiar with the system of education existing in France, it is obvious that the scheme outlined above closely resembles it. The curriculum, although somewhat influenced by Anglo-American institutions, has a basically French structure. The unit is the *certificat*; that is, a homogeneous series of lectures and laboratory periods covering a period of one year and involving several instructors. For instance, a *certificat* of Comparative Morphology of Plants comprises: Comparative Morphology of Fungi (30 hours), of Algae and Bryophytes (30 hours), of Vascular Plants (30 hours),

Dr. Jean-Louis Tremblay, Quebec

YACHT OF THE FACULTY OF SCIENCES
USED IN THE GULF OF SAINT LAWRENCE FOR PREWAR OCEANOGRAPHIC AND BIOLOGICAL INVESTIGATIONS.

Phanerogamy (30 hours), Geobotany (20 hours), Phytopathology (10 hours), Economic Botany (30 hours), and an equivalent number of laboratory periods.

With three such certificates in any one, two, or three branches of science (Mathematics, Physics, Chemistry, Biology, Botany, Geology) to his credit, the candidate receives the *license* (L.Sc.), which is equivalent to the American B.S. with honors. Practically, the license proves most valuable to teachers in primary and secondary schools and large numbers obtain it in the years following their graduation from normal school.

Also, it is considered a necessary step to either the Master's degree (M.Sc.) or the doctorate (D.Sc. or Ph.D.). As concerns these degrees, there is little to say: the formalities, studies, and research involved are very much the same as in any other North American university, or any European institution, for that matter.

Professional organization. Scientific societies have existed in French Canada for over a century, some of them devoted to pure science, others to the advancement of professional standards.

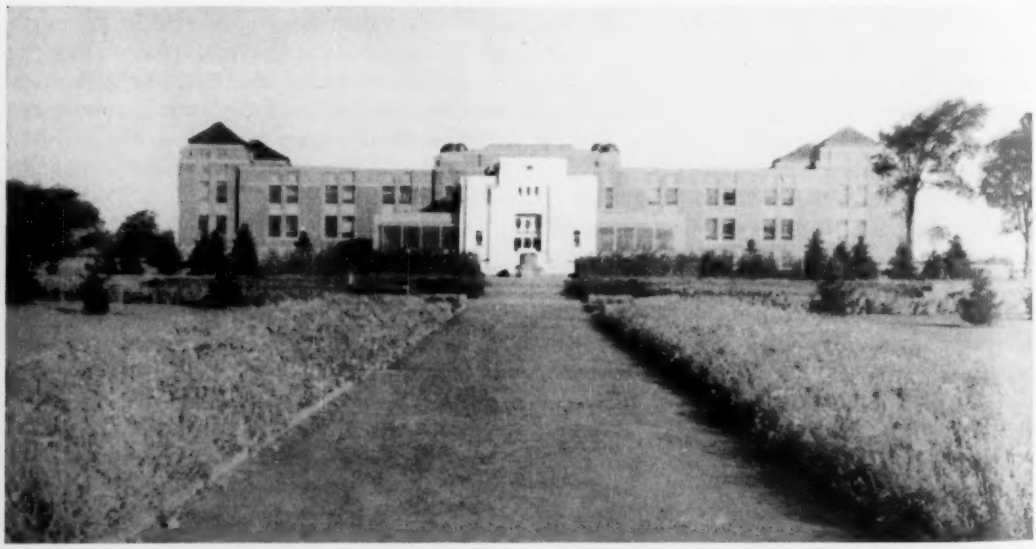
Today forty-five of these societies are affiliated with the *Association Canadienne Française pour l'Avancement des Sciences* (ACFAS). This federation, built on the model of similar organizations of longer standing in other countries, was founded in 1923. Its period of greater efficiency, however, was initiated in 1933 with the first an-

nual convention, held in Montreal. The impetus given to research since then has been truly remarkable. Many scientists, especially those not inhabiting the larger centers, were greatly encouraged and stimulated by yearly contact with fellow workers. This especially applies to technicians employed by various state departments (Agriculture, Forestry, Mines, etc.). The role played by the ACFAS is somewhat similar to that of the various American State Academies of Sciences. Such institutions provide a platform for scientific workers; an occasion for exchange of ideas and for discussion. They also stimulate research and publication. I believe that the output of French-Canadian research could be shown graphically to have marked a decided and unfailing upward trend since 1933.

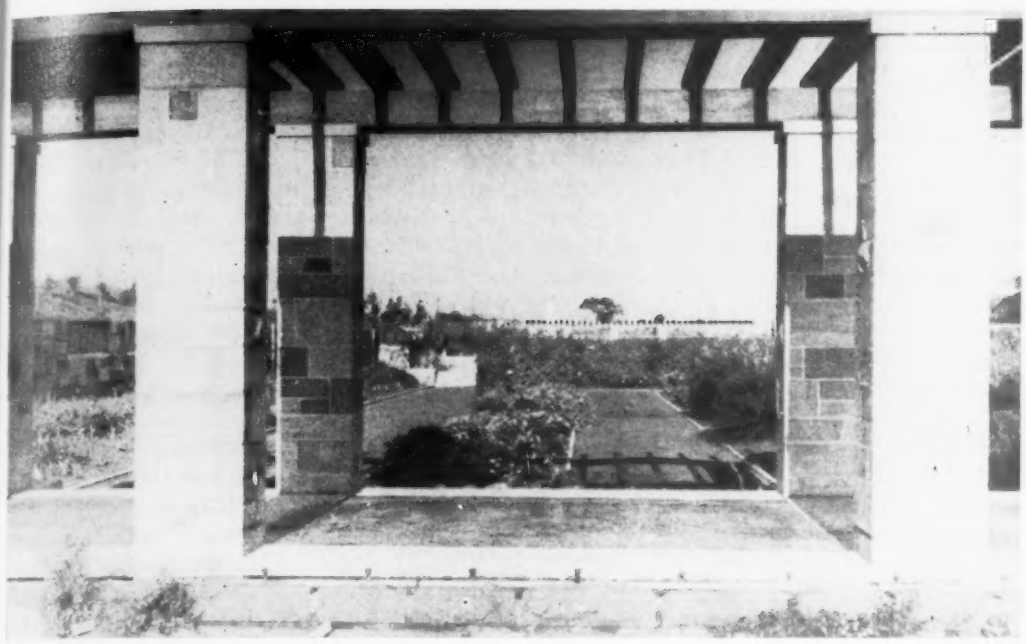
Many of the scientific societies involved, however, had reached extensive development even before then. Such is the case of the *Société Canadienne d'Histoire Naturelle*, founded in 1923 and open to amateur as well as professional naturalists. The greatest achievement of this society is its sponsoring of the *Cercles des Jeunes Naturalistes*. The junior naturalists club aims to "train its members in the study, observation and sympathetic comprehension of Nature in all its aspects."[17] The first one was founded in 1931 by Brother Adrien, C.S.C., and in 1943 there were over 900 clubs with more than 28,000 members. Branches had been established in the other provinces of the Dominion and in other parts of the world where French is spoken: in France, in the United States, in Egypt, in India.

The history of that movement is a most engrossing one[18] and it is very important to the scientific development of the last twenty years in French Canada. The dominating figure has been Brother Marie-Victorin, the great botanist whose influence has extended beyond his chosen field and even beyond that of the natural sciences. Many of the most promising young scientists of today in our universities received the revelation of their vocation and their first training in one of these junior naturalists' clubs. Today there is a rather sharp distinction between two generations in respect to early-acquired knowledge of the natural environment.

No less important was the foundation, approximately at the same time in Montreal and Quebec, of distinct Science Faculties. In Quebec Monseignor Alexandre Vachon—a distinguished chemist, now Archbishop of Ottawa—with the dynamic collaboration of Mr. Adrien Pouliot, engineer and mathematician, created an *Ecole Supérieure de Chimie*, which was enlarged into the *Faculté*



ADMINISTRATION BUILDING, MONTREAL BOTANICAL GARDEN
CREATED IN 1936, THE GARDEN IS MOST MODERN AND WILL BECOME ONE OF THE LARGEST IN THE WORLD.



PART OF THE PERENNIAL GARDEN, MONTREAL BOTANICAL GARDEN

des Sciences de l'Université Laval. In Montreal it was also a chemist, Dr. Georges Baril, who was the soul of a young but progressive Faculty of Sciences. Economic pressure and the need for specialists in many fields not covered by the already existing professions were potent factors in the promotion of these independent science faculties. The men of vision who created them have amply proven their usefulness.[19] They have done more than that; they have given the pure sciences a status which they did not officially possess till then.[20] It can be said that independent research only then became possible. Today, the various departments of these two faculties of sciences at Montreal and Quebec are well organized in new buildings and have laboratories adequate for practically all phases of research. Even more important, their staff comprises an increasingly large number of young scientists trained in the American and European universities. Some of them already have attracted some measure of attention by their publications.

Much could be said of scientific societies—medical, legal, agricultural, chemical, and otherwise. Some have a fairly long standing and have rendered many a service. But I cannot do them all justice here. Let me mention, however, the Royal Society of Canada, which has elected many French-Canadian members. This national academy has done much, together with the National Research Council, to encourage and to promote research.

Technical adaptation. In the fields of agriculture, silviculture, mining, and the exploitation of natural resources generally, we have fine examples of the French Canadian's adaptation to his North American background. Many colonists, from the beginnings of the French regime, felt very keenly the tremendous possibilities of this new country and early abandoned all ideas of modeling it on the agriculture and general economy of the mother country. This led to many conflicts, the most notorious being that of General Montcalm and Governor Vaudreuil.[21] People like Maisonneuve, the founder of Montreal, Jeanne Mance, Jean Talon, Pierre Boucher de Boucherville were authentic Canadians and constantly sought for adaptation and not imitation.

At the beginning of the British regime, the farmers of Lower Canada had already created a hardy and efficient race of general-

purpose horses. They had also bred a strain of cows for their excessive frugality and hardiness. Both these breeds are now recognized in international exhibitions and have closed stud books. A system of agricultural economy gradually became established which was both rational and efficient. It implied few scientific principles, if any, but allowed the *habitants* of the old parishes bordering the Saint Lawrence to make a living—indeed in many cases to become well-to-do.

But presently the need was felt for improvement, and this time French Canada did not look to France, but to the United States to help it solve its problems. Young silviculturists and agronomists, trained as well as they could be in our schools, were sent to Cornell, Harvard, Yale, Iowa State, Massachusetts State, Michigan. They were usually gifted students, quite capable in spite of the shortcomings of their basic training of following advanced courses. Also, they managed, upon their return, to adapt their knowledge to the conditions of Quebec; edaphic, climatic, cultural, economic.

The job they have done is by no means perfect. It was not always understood by the public and by the government that it was worth while to spend a lot of money on scientific training and research. Because of this lack of appreciation, our agronomists and silviculturists did not manage to impose the high scientific standards of which they had dreamed. They were forced by circumstances to be, above all, practical men. Many of them never rose above that level. But all realize today the need for the technician of a broader scientific outlook.

The damage done by man in depleting the natural resources of Canada is no doubt considerable. The lack of proper management leaves us today facing unforeseen problems. These, however, may not be as great as those of many American States where man's remodeling of the landscape has created a state of unbalance nowhere nearly as beneficial as had been hoped.[22]

This whole subject of the technical adaptation of the French Canadians to their landscape and of the scientific principles invoked by them—even implicitly—calls for the preparation of an extensive book. Everett Hughes, of the University of Chicago, has given us a valuable contribution in that sense.[11] We can hardly draw the whole picture here, important as it is to our subject, but we can at least try to delimit which factors are scientific and which social and political.

Let us look, in that light, at the forests, the land, the fisheries.

The forests of the Laurentides have been cut abusively in districts generally unsuited to agriculture and opened under the guidance of well-intentioned but poorly-documented missionaries. Those of the Northland have been mostly ceded to capitalists of diverse (non-French-Canadian) origins, in whom it is not surprising to discern no thought for the future. That French-Canadian governments at Quebec have allowed this to happen is due only in part to diverse forms of political and economic pressure. The general feeling of the inexhaustibility of our woodlands is only now beginning to wear off. The very wise silvicultural policy of the Swiss, French, and Scandinavians has only recently appeared urgent here.

As for the land, it has long been managed under the system of private ownership by routine unimproving methods. Regional specializations, like dairying, are by no means new, however, and many of them can be said to have been successful for a number of years; for example, the cultivation of tobacco in the Joliette area, of vegetables on Isle d'Orléans and Isle Jésus, of flax in Charlevoix, of peas in Gaspé. But what a tremendous need there still is for experimentation! Very few new varieties have been created for the particular conditions occurring in Lake Saint-Jean, in Gaspé, in Abitibi, or even, for that matter, in Quebec or Rivière-du-Loup. The Montreal plain has produced the famous Montreal melon[23] and the Oka melon, but not a single variety of tomatoes, lettuce, celery, potatoes, and other truck crops. American and Ontarian varieties have been tested and to a certain extent bred locally, but there has hardly been a general breeding program to suit the specific needs of the province of Quebec.

I feel bound, however, not to pass over silently the work done at the Central Experimental Farm at Ottawa and at Macdonald

College, P.Q. That French Canadians have played a decidedly minor role in both these institutions can be accounted for in many ways, not all of which are to our advantage—and none of which, I am afraid, will show national unity in a very favorable light. However that may be, it is not surprising that much of the work at Ottawa was concentrated on the needs of the predominantly agricultural and highly productive western provinces, and at Macdonald College mostly on the benefit of the English part of the province of Quebec, once conceded to the United Empire Loyalists, the Eastern Townships.

No picture of agriculture in French Canada is complete without an outline of the work of the technical agriculturists, the *agronomes*. These men, trained in one of our three agricultural schools (*Institut Agricole d'Oka, Macdonald College, and Ecole Supérieure d'Agriculture de Sainte-Anne-de-la-Pocatière*) and awarded a B.S.A., now constitute a recognized closed corporation, equal in standing to that of the lawyers, pharmacists, physicians, and engineers. Most of its members are employed by the state. They are mainly responsible for the many intelligent applications of agricultural science to local needs: for the devising of drainage systems, the introduction of new cultures and of fertilizers, the diffusion of pure-bred stock, and so on. Some of these men have been pioneers in more ways than one and deserve much credit. Their role in bringing science to the people can hardly be overestimated; today every farmer knows the meaning of protein, vitamins, and pure-bred lines because he has been made conscious that such things were not out of a textbook but living things in his own back yard.

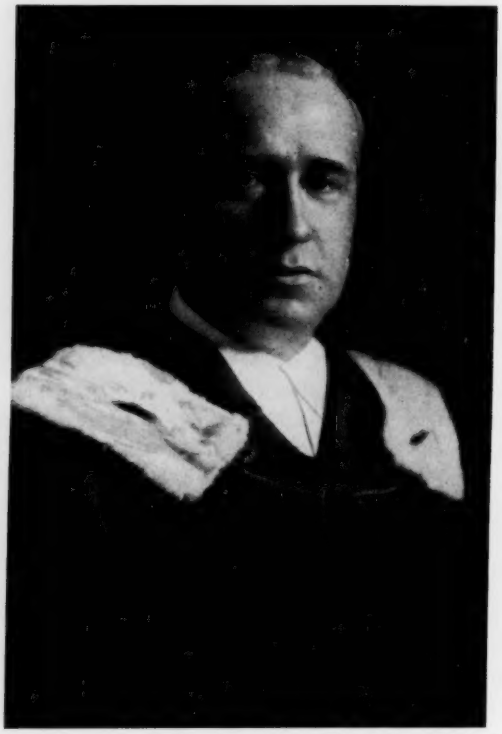
As for the immense wealth represented by the fisheries of French Canada, that is in some ways a moot subject. The impact of science on the fisheries of the Gulf of Saint Lawrence has been felt none too keenly in the past by the French-Canadian fisherman. He has recently been freed by the co-operative movement from an age-old, quasi-feudal servitude imposed upon an ignorant and poor population by wealthy foreign companies eager to keep cheap labor cheap. This situation, now nearly at an end, may have been to the detriment of the local human population but was not noticeably so to that of the fisheries themselves. In fact these same companies were always eager to adopt new methods, especially of preservation.

The case of salmon fishing and the general relationship of sport and commercial fishing also involve political and economic factors present elsewhere and, I think, to more or less the same degree. If the sportsman's intentions are not to be questioned, surely there is as much need for him as for the commercial fisherman to call for the advice of the biologist, especially the ecologist. Much unwise legislation, in all parts of the world, is due to lack of biological knowledge or to ignorance of such as is already available. On the whole, in Quebec the protection of our biological resources is in many ways ahead of that in other parts of this continent. Our legislation has usually been based on sound, if summary, information and has proved fairly efficient.

Original contributions. It is fitting, in concluding this review of science in French Canada, to give a little detail about the achievements of some of the men of science who have been bred and have worked in the atmosphere described above. Very few of them have gained international renown. All of them have considerable merit and deserve to be better known outside our frontiers. All have one thing in common, and that is the pioneer spirit. They are men who have felt very keenly the stimulus of new problems and they are the more typical French-Canadian in that their work can be seen to have responded to the requirements of their cultural and geographic environment.

And perhaps first of all, I should name Captain Bernier, the grand old skipper of the *Arctic*, an exploring vessel dedicated to the discovery of new lands in the frozen North and to the investigation of their resources. Many useful data—geographic, geological, botanical, and zoological—have resulted from his famous trips. He was born at l'Islet, on the magnificent Saint Lawrence below Quebec and died at Lévis in 1934 at the age of eighty-one.

Pierre Fortin, the initiator of fisheries research in Canada in 1852, was another sea-minded Canadian. He was a man of con-



Dupras & Colas, Montreal

BROTHER MARIE-VICTORIN, 1885–1944

LATE DIRECTOR, BOTANY DEPARTMENT, UNIVERSITÉ DE MONTRÉAL AND OF THE MONTREAL BOTANICAL GARDEN.

siderable intellectual curiosity and also a man of ability and endurance, for he was sometime physician, member of Parliament, magistrate, and scientist. "He described the fishes (naming a few species) as well as the fisheries, and developed a system of detailed fishery statistics that was adopted for the rest of Canada and that has given this country these basic data for fishery research, collected in more detail and continuously for a longer period than holds for any other country."[24]

In more recent years investigations of our marine biological resources have been very much to the fore. The present Archbishop of Ottawa, Monseignor Vachon, who was then dean of the Faculty of Sciences at *Université Laval*, organized the *Station Biologique du Saint-Laurent*. There were carried on systematic explorations of the marine fauna of the Gulf of Saint Lawrence, studies of the life-habits of such important species as the herring, the cod, the lobster.

Professor Georges Préfontaine, head of the *Institut de Biologie* at the *Université de Montréal*, co-operated with the *Station Biologique du Saint-Laurent* from the first on many of these projects. But his life's work has been the study of the Atlantic salmon, on which he has published several papers and is still active. Dr. Préfontaine was also born in the open reaches of the Lower Saint Lawrence, at Isle-Verte, and that may be a significant fact. He, like Pierre Fortin, first got his M.D. degree. Then he received a Rockefeller scholarship and studied several years in France, mostly at Strasbourg and Roscoff. He has exerted considerable influence in the shaping of French-Canadian scientific organizations, especially on the teaching of biology and the initiation of research at the *Université de Montréal*.

The history of botany in French Canada is rather longer and more eventful than that of the other sciences.[25] Its modern phase started with Provancher and Brunet (mentioned on page 261). However, it was seemingly interrupted until almost the beginning of World War I.[26] It was then that a modest brother of the Christian Schools became known to a number of correspondents in France, England, South Africa, the United States, and elsewhere: Brother Marie-Victorin, who died on July 15, 1944, at the age of fifty-nine.

It will prove difficult in a few paragraphs to summarize the accomplishments of Marie-Victorin and to define his influence. In the first place comes the personal, creative part of his work. He had no less than eighty-five scientific publications to his credit, not counting literary and popular writings.[27] His best known work is no doubt the monumental *Flore Laurentienne*,[28] a masterly piece of work, containing not only a description and illustration of the species of plants growing in the Saint Lawrence Valley, but a wealth of footnotes, most of them resulting from personal observation and deduction. The accurateness and richness of this work is paralleled only by its usefulness to botanists, agronomists, silviculturists, and others in all of eastern North America.[29]

Therefore, Victorin was not only a florist in the old-fashioned sense but one of the most significant phytogeographers of his genera-

tion. Though he repeatedly acknowledged the influence of Professor Fernald of Harvard,[29] his point of view was original and inspired by a vast traveling and reading experience. His contributions to the geobotany of North America[31] will stand as landmarks in the development of that science. More recently, he turned to tropical botany and published several contributions to the flora of Cuba.[32]

But that was not his whole work. He created two large institutions: the *Institut Botanique*, which is the Department of Botany of the *Université de Montréal*[30] and the Montreal Botanical Garden. The latter, although it was created only in 1936 and although its development was partly arrested by the war, is one of the finest and best-organized institutions of its kind in the world.[33] In scientific circles, Marie-Victorin's influence can hardly be overestimated. He was the dominating figure in the junior naturalists' clubs, which he inspired and guided for years, as also in the *Association Canadienne-Française pour l'Avancement des Sciences* (ACFAS), of which he was one of the charter members. He determined and helped to forward many a scientific vocation in practically all fields of science.

One of his lifelong friends was Dr. Léo Pariseau, a man of very heterodox ideas. Pariseau, who passed away in January, 1944, was one of the finest personalities ever produced by French Canada. On the surface, he had much of Voltaire, being a nonconformist and extremely intolerant of all forms of stupidity, dishonesty, hypocrisy, and even foolishness. But he had even more of Don Quixote and Galahad, for all his life has been a crusade. It is no wonder that such a man often found himself at odds with the educationally ruling class, the clergy. As a matter of fact, he has sometimes been taxed with anticlericalism. But among all the clergy there are no doubt very few as godly men as he. The very reverence he professed for truth and for honesty proved unbearable to the more reactionary and self-satisfied members of an unthinking society.

Pariseau was a distinguished physicist and has published many papers on electrophysics and electrotherapy.[34] He was a living encyclopedia and had assembled, in a lifetime, a collection of ancient scientific books, unique in America, which he had recently donated to the *Université de Montréal*.[35] Most of all, however, he has kept burning the torch of independent thinking. He has fought all forms of dogmatism, all brands of scientific heresy and charlatanry. He has few direct pupils, but most French-Canadian scientists owe to him much of their awareness of scientific issues and of the relative peace which now protects honest research.

Dupras & Colas, Montreal

DR. LÉO PARISEAU, 1883–1944

A PHYSICIAN AND PHYSICIST, HE WAS ONE OF THE MOST BRILLIANT PERSONALITIES OF FRENCH CANADA.

There are quite a few others whose merits would entitle them to be named here. Among them are many professors who came from France and to whom Canada owes a great debt. But let the brief outline of these few personalities serve as a cross section through the French-Canadian scientific milieu. Today there are a large number of men, mostly between thirty and forty, whose work may turn out to be important tomorrow. In the postwar world let us hope for new opportunities in research. Many young French

Canadians have received a broad training in Europe or in the United States and are even now prepared to embark upon the study of significant problems. They all feel that what they have borrowed from other nations they are now bound to return in the form of original contributions to the science they are serving.

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EVOLUTION OF THE WHEEL

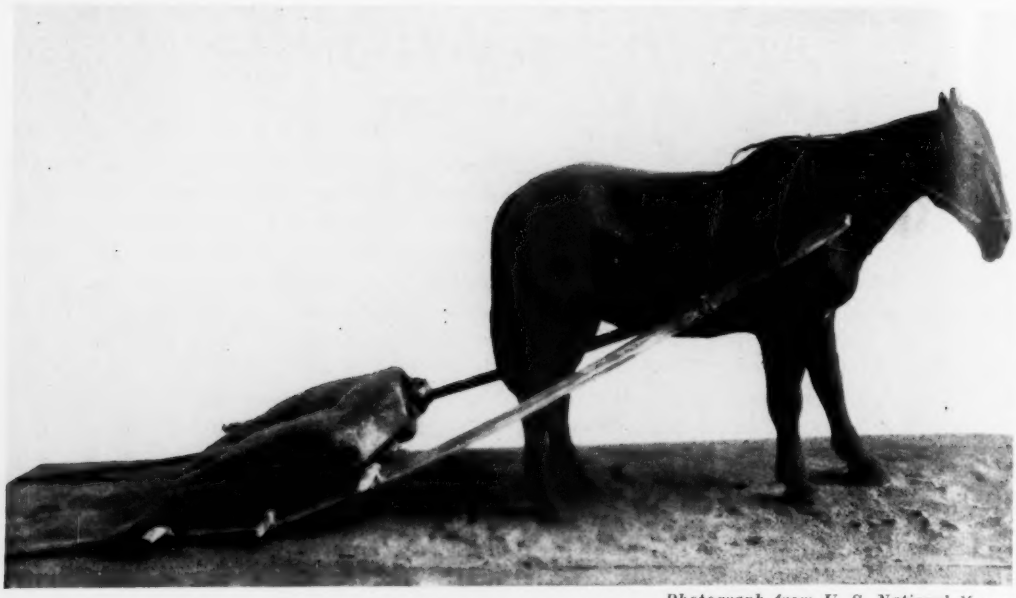
By H. E. KLEINSCHMIDT

HISTORIANS who trace the evolution of man from naked savage to civilized being seldom fail to mention that the wheel is one of the five or six devices that made his progress possible. In what way the wheel served to advance him out of his animal state, and how the wheel was invented, is left unsaid, except for general comments about rollers and runners. This unsatisfactory explanation of how the roller became a wheel or the runner a chassis is not the fault of the historian, exasperating as it may be to the reader, because the wheel was developed long before history was recorded and because the remains of primitive man's handiwork are too scanty to reconstruct the steps in the discovery of the wheel principle.

It is easy to test the absolute dependence of modern man's existence upon the wheel. The sugar he pours on his breakfast cereal was delivered to him on a wheeled truck and, before that, rode in a wheeled freight car. The cane from which it was extracted was hauled in a crude cart, then perhaps, on a "dinky" railroad to the mill where it was ground up by a bewildering contrivance of wheels and rollers. Similarly, his milk, bread, bacon, and coffee came to his table by means of wheels. Donning his hat and coat, manufactured and delivered to him with the aid of wheels, he rushes to the bus or street car and he depends upon the elevator to hoist him safely to his office. There he sets in motion various kinds of office machines, all of which include wheels in their construction, as he supervises a factory, a railroad, or a sales campaign requiring travel and transportation. Sudden stoppage of all wheels would mean death for our way of living; if not sudden, none the less sure. Transportation and machinery make our present manner of life possible. The ultimate unit of land transportation and the essential unit of machinery is the wheel. Peacetime intercourse as well as modern warfare are inconceivable without the wheel. One is tempted to say sweepingly that without the wheel civilization would have been impossible.

And yet, who knows? At least it is interesting to speculate whether or not, if this ingenious mechanical device had not been discovered, man would nevertheless have found a way of solving his transportation problems. After all, the wheel is but a means of reducing friction to a minimum so that loads may be drawn over a surface from place to place. Without the wheel man might have exercised his ingenuity in overcoming friction in other ways. Modern physics and chemistry suggest that the easy gliding of one body over another may be feasible. For example, electric currents can be made to repel objects as well as to attract them, and the chemistry of lubricants is just beginning to be understood. If there were no wheels, it is possible that science would find a way of utilizing other methods for transportation. Furthermore, air transportation promises to supersede much of our present laborious land transportation. If it be argued that the airplane propeller (or the ship's propeller, for that matter) is a wheel, it may be countered that the propeller is in reality a screw and not in any sense a wheel. The mechanical principles of the propeller and of the load-bearing wheel are widely different. Substitutes for the wheel used for the transmission of power might also have been found if this handy device had not been available. Pulleys, gears, and fly-wheels are indispensable in our present machinery, but who will contend that, if absolutely necessary, wheel-less machinery could not be devised to do the work now accomplished by wheels. At any rate, the wheel is here, serving us constantly and efficiently, and its history reaches back into the dark gropings of primitive man.

Strangely, there are no wheels in nature, although most of man's essential inventions have apparently been suggested by natural phenomena. Primitive man, for example, found a variety of uses for the forked stick, and to it we may trace such varied contrivances as the plow, the table fork, and probably the hammer and the pillar for roof support. A duck paddling in the pond is a



Photograph from U. S. National Museum

INDIAN TRAVOIS

"natural" boat, and soaring birds undoubtedly put the idea of flying into the mind of man. Eli Whitney solved the problem of ginning cotton by observing a fox clawing through the bars of a chicken coop in a vain effort to capture a hen. The animal's claws brought away feathers but left the hen otherwise unharmed, and Whitney caught the idea of mechanical claws working through a restricting grating which would pull cotton fibers from the boll and leave the seeds behind. But no such help from nature was afforded man in his quest for a wheel. Although locomotion is a distinguishing characteristic of animal life, and although fins, wings, and legs are abundantly bestowed upon living creatures, nothing in nature is known to move about on wheels nor to use wheels in any manner whatsoever, physiologically. There are a few so-called "pulley muscles" which turn corners, but the pulleys are nothing more than spicules of bone. Oliver Wendell Holmes, in a sparkling essay on "Walking," was led into the error of assuming that human locomotion is a wheel-like action. Each leg, he pointed out, is a spoke hinged at the knee, the upper end of which pivots at the hip while the feet are but sections of the rim. But the important functional difference between legs and wheel is this: walking is a reciprocal motion, whereas the wheel moves in a continuous direction. Reciprocal motion is wasteful; power is consumed to start and to stop motion, whereas the continuous revolution of the wheel benefits by momentum. Even if Holmes had proved his point that legs are wheels in principle, by no stretch of the imagination would walking ever suggest wheel construction to the mind of man. The wheel is a purely man-conceived invention, created out of the void of his own mind. Doubtless God can make a wheel, but evidently He never did.

The Disc Wheel

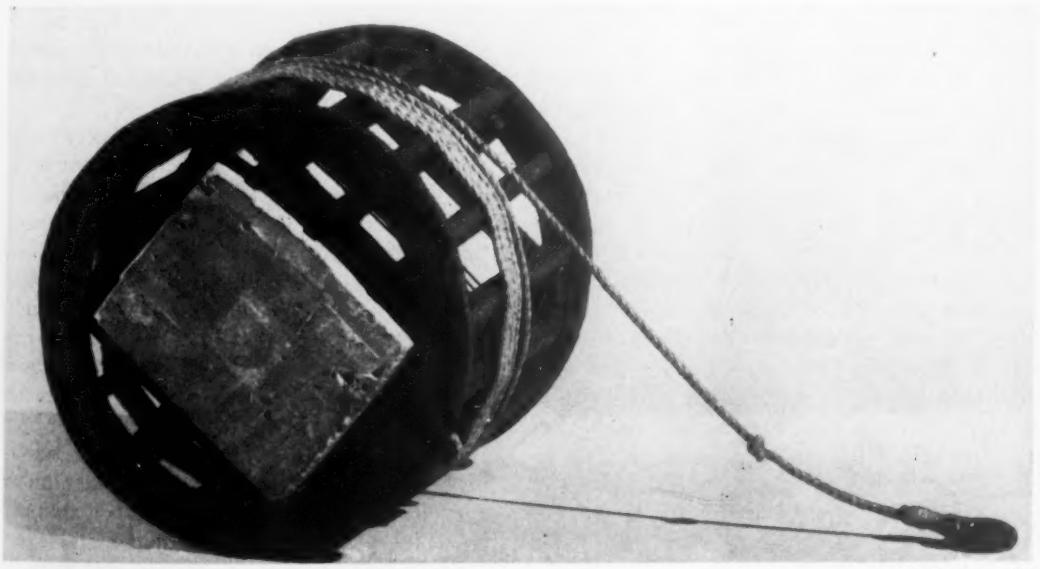
The wheel is not the product of a single genius but the result of slow evolution, and it arose out of man's trial-and-error efforts to move loads from place to place. The wheel of the Western world is a direct descendant of the Egyptian wheel, records of which go back to at least 2000 B.C. From the Egyptians the wheel passed successively to the Assyrians, Phoenecians, Greeks, and Romans and then to Western Europe. The fact that the Greeks claimed to have received the wheel from the gods testifies to their high evaluation of it and probably to the obscurity of its origin. Mention of the wheel is made in the Old Testament (the ark of

the covenant was carried on a cart drawn by oxen) but without description, and it is possible that the ancient Hebrews derived their wheel from the Egyptians.

Apparently a wheel of a different type also evolved independently in Asia. At least the wheel used in the present day in primitive parts of Manchuria, and undoubtedly of ancient origin, is of a type of construction entirely different from that of the spoked wheel of the Egyptians. Variations of this wheel may still be seen in India. In burial grounds in China wheels of many spokes, dated about 500 B.C., have also been unearthed. These Chinese wheels seem to be related to the Egyptian wheel; nevertheless, one is inclined to surmise that the Chinese wheel developed independently of the Egyptian.

How the wheel actually came into being is not known. But certain scraps of prehistoric remains, bits of ancient drawings, and vehicles which have evidently not changed their form for many centuries, permit us to conjecture how one step led to another until the trick of moving burdens on wheels was learned. Two of prehistoric man's mechanical devices must be considered: the runner and the roller.

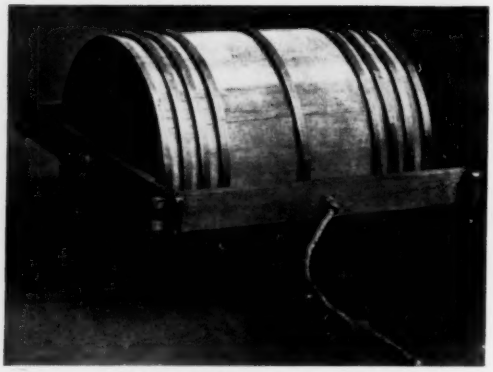
Loads that cannot easily be carried by man or beast may be dragged. Dragging is made easier if the load is mounted on runners. By cutting a forked stick from a tree, primitive man was able to make a serviceable sledge of two runners which bore the load while the main branch served as handle or shaft. Such use of nature's ready-made tool seems to have been common all over the world. A variation of that device is the American Indian's travois, a kind of sled made of two saplings held together with thongs. A pony is hitched between the forward ends of the saplings very much as a horse is harnessed between the shafts of a wagon. By arranging the saplings as runners in parallel, friction was further reduced, and this discovery probably led to the construction of a simple sled. Easy to construct, the crude sled or sledge has served man well and still continues to do so—on farms for moving heavy stones or other unwieldy loads and for construction work where the terrain is too difficult for wheels. In frigid climates the sled has reached all but mechanical perfection. The Eskimo sled, for example, though fashioned by primitive workmen with the crudest of tools and materials, is an example of functional beauty and efficiency, while Russian, Polish, and Hungarian sleighs, drawn by swift horses and lavishly decorated, bespeak the cultures of those peoples. Wherever snow and ice pro-



Author's model

A ROLLING STONE

GRECIAN METHOD OF TRANSPORTING A BLOCK OF STONE. FROM A MODEL IN THE SMITHSONIAN INSTITUTION.



Photograph from U. S. National Museum
ROLL OUT THE BARREL
PRIMITIVE WAY OF HAULING A TOBACCO HOGSHEAD.

vide a slick surface, the runner is a most useful means of carrying loads but under other circumstances its usefulness is definitely limited.

The roller is commonly said to be the forerunner of the wheel. But how did it evolve? As no one knows, we are free to speculate—which we shall do in the hope of discovering at least a plausible explanation. As in studying natural evolution, one may start with the roller as origin and pursue several paths, some of which end blindly or reach a point beyond which there was no further development. How our hairy ancestors, whose only tool and weapon was a club, discovered the friction-overcoming qualities of a roller is anybody's guess. Rounded stones roll down hill; the feathery seeds of the tumbleweed roll when driven by the wind; a log may be rolled with greater ease than dragged head-on. Some such observation no doubt led primitive man to shape his loads, when possible, in spherical or cylindrical form.

That the rolling-load principle was highly developed and carried over into civilization is attested by the manner in which the ancient Greeks transported to Athens the marble blocks for their magnificent temples. The columns which support the roofs of their buildings were quarried miles away and shaped into cylinders there, each section being about twice as long as the diameter of the circle. Holes were drilled in the ends of the cylinder at the pivotal center. A wooden framework was then fashioned around the cylinder, with pegs that fitted into the drilled holes. Then, by pulling the framework, the cylinder was easily rolled to the temple site and there lifted into place. Here we find a hint of the wheel hub revolving around an axle. But it is not a wheel capable of carrying a load. It is itself the load and merely rolls. The identical arrangement has been used until recently in American transportation. Before railroads were common, huge casks of tobacco were fitted into frameworks like those of the Greeks for moving pillars. Mules were hitched to these casks and so were rolled for miles over country roads to the steamboat landing where they were taken aboard.

The Greeks also invented a device for moving square and oblong blocks of marble and stone. It was a kind of skeleton cylinder made of wood and closely resembled a squirrel cage, in which the block of marble was encased. It consisted of two strong hoops connected at their peripheries by equally-spaced parallel sticks. Around the cylinder the movers wrapped a line, which, when pulled by oxen, unwound itself and rolled the cylinder with its load. In this contrivance there is neither hub nor axle. But the hoops, running parallel to each other on the ground, remind one of the rims and tires of two wagon wheels. Still, this is a rolling load and in no sense a wheel. The rolling load is serviceable today—think of barrels made to roll and of the huge spools on which telephone cable is wrapped and transported—but in the evolutionary scheme it does not lead us to the wheel.

Another early use of the roller was to place it under a flat-surfaced object and then push or pull the load. The roller had to be replaced over and over again, which meant stopping, carrying the roller forward, lifting the front end of the load, and placing the roller again beneath it. Two rollers made the task a bit easier, and three rollers obviated the necessity of lifting the forward end of the load each time a roller had to be reinserted. With the aid of the roller the Egyptians built their mighty pyramids, moving huge blocks of stone up inclined planes, and with exactly the same technique we now move heavy pieces of machinery, and even houses, from place to place. But that is as far as the roller, of itself, developed, unless one wishes to marvel at the smooth efficiency

Photograph from U. S. National Museum

ROMAN CART

of the roller bearing, which is still a roller and not a wheel.

We make, therefore, a third exploration, starting with primitive man's roller which, in all likelihood, was the section of a tree trunk from which the bark had been peeled. This roller he used to move his sledge, crudely made of two runners joined by cross pieces. On this sledge he moved heavy objects that could not well be moved alone. Coming to difficult spots, he placed a roller under the runners; and that greatly eased friction. With repeated use the roller would wear down where the runner passed over it. Eventually two grooves would ring such a roller where the runners came in contact with it. The deeper these grooves, the more efficient such a roller becomes for the reason that the circumference of the roller which passes over the ground is greater than the circumference traveled by the runner. Assume that a roller has a circumference of 1 foot. If the runner is 3 feet long, the roller will move forward 3 linear feet before it has to be changed. In the meantime the runner has gained an additional 3 feet by passing over the roller. Thus the load has been advanced 6 feet with one change of roller. Now assume grooves worn into this roller so deep that the circumference of the grooves is $\frac{1}{2}$ foot. Six revolutions of the roller would be made before the need of changing the roller arises, thus advancing the roller 6 feet, and the runners would have advanced $6 \times \frac{1}{2}$ feet or 3 feet, making a total of 9 feet advancement of the load. Thus, the worn runner, though not as strong as when new, would be 50 per cent more efficient in its load-advancing capacity than one of the same size not worn down.

Eventually the grooves would wear so deeply that the roller would break. In replacing it with a new one, it is conceivable that a man with even a glimmer of intelligence would cut grooves into the new roller like those of the worn roller when it was still at the height of its efficiency. Having gone through this process several times, he must have asked himself sooner or later what useful purpose, if any, was served by the mass of wood lying between the grooves. Experimentally perhaps, he removed it with his axe —and produced a roller much lighter in weight. Such a roller is, in general design, the same as that of the two car wheels held together with an axle, now used on railroad cars.

The next step was a crucial one—holding the roller (now wheels and axle) in place underneath the runners. It was achieved no doubt by means of pegs driven into the underside of the runner near its mid-point. When that was done, a crude cart had been invented.

Further progress was technically impossible until the saw was discovered, which was comparatively late. According to Greek tradition the saw came into being out of the

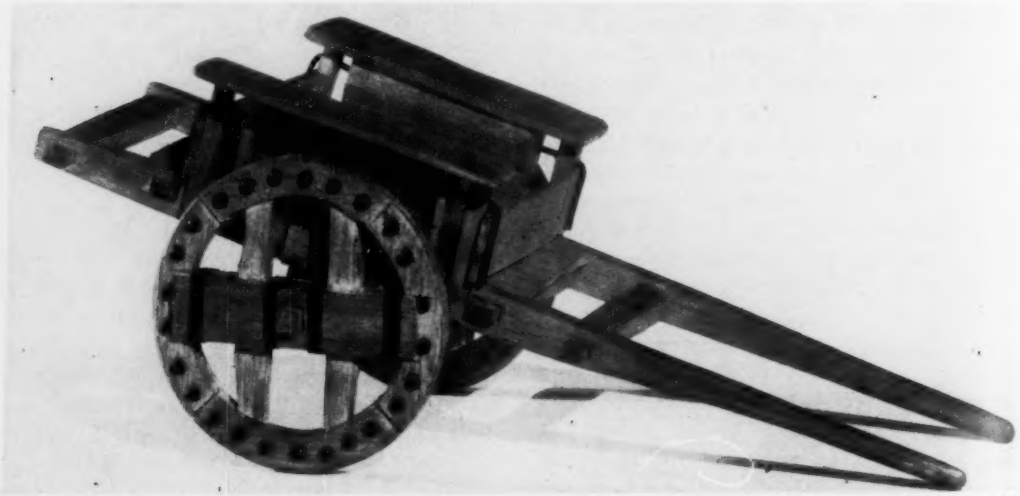
efforts of an early metal craftsman to model the jawbone of a serpent in iron. True or not, the metal-toothed tool opened a new field of technology for man and made possible, among other things, the sawing of a disc from the trunk of a tree. By drilling a hole at the center of the disc, the end of an axle could be driven into it. The larger in diameter the disc and the smaller the axle, the more efficient would be the unit consisting of two wheels and axle. With the greater ease of transportation made possible by such a pair of wheels, interruption caused by the need of changing rollers was obviated, and that made it possible to use animals to pull the load. Distance was shortened, time and energy were saved. All this no doubt encouraged the interchange of goods—the beginning of commerce. And along with the development of the wheel and axle probably also went the further refinement of the sledge, so that it became a chassis and body, and the entire ensemble, a cart.

Accident may have led to the discovery that a wheel may be made to revolve about the axle instead of with it. One can imagine that a wheel, worked loose from its axle, might temporarily have been held in place by means of a peg driven through the distal end of the axle. Then why not construct the wheel and axle so that the axle would remain affixed to the chassis and permit the wheel to revolve about it? Of course the wheel would wobble unless the axle fitted the hole with a fair degree of precision. That the mastery of this improvement was not easy is implied in some of the wheels of the Orient—Manchuria, China, India—for some of these wheels are still fixed permanently to the axle.

At its best the solid disc wheel sawed from a tree trunk is heavy, clumsy, and not easy to make. The size is limited by the diameter of the tree trunk—and size is important, for a large wheel travels more easily over rough terrain and wears out less quickly than a small wheel. Furthermore, parallel saw cuts are more difficult to make through a large log than a small one. Weight is reduced by cutting the disc as thin as possible consistent with strength, but a thin wheel presents less revolving surface for the axle than a thicker one and hence will more easily wobble. These limitations were overcome when man became a little more adept with tools and learned to use slabs of wood, or boards, which in turn led to the development of the spoked wheel.

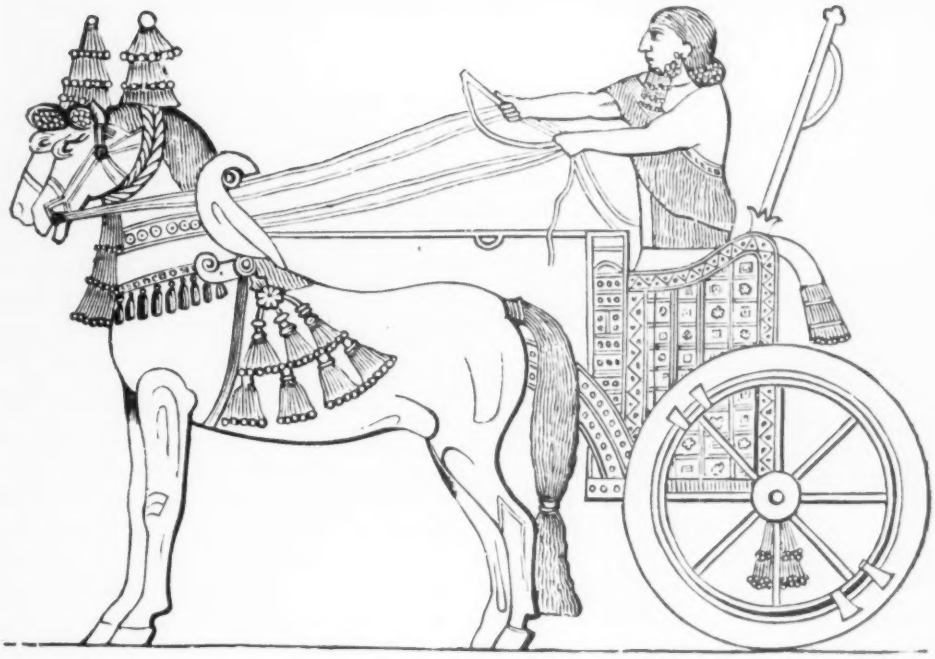
The Spoked Wheel

Two boards fastened together on their flat sides with the grains crossing at right angles are very strong (we are just beginning to appreciate the strength of laminated plywood). If the boards are 6 inches wide, a 6-inch disc can be cut from them which will be reasonably strong. A hole drilled in the center makes the disc a wheel. If the wheel



Author's model

SIBERIAN CART



Photograph from U. S. National Museum

ASSYRIAN CHARIOT

is to be larger, say 18 inches, three 6-inch boards laid edge to edge and crossed by three similar boards at right angles may be tightly joined for the purpose. Still stronger would be a wheel made of three such layers, the grains of the wood in this case crossing at angles of 60 degrees. Wheels of that type are actually known to have existed, for example, on farm carts of the Roman Empire period.

The greatest wear of such a wheel would be at the rim. A tire carried around the rim would protect it, and when worn out, could be replaced, thus prolonging the usefulness of the wheel. How the tire first came to be used is shrouded in mystery. It is conceivable that a split sapling may have been fastened to the outer edge of the disc. There is a hint of this construction in an old Egyptian wheel in which the fellies are made of inner and outer parts and are lashed together with thongs. This may have been a carry-over of the more primitive method of lashing an outer to an inner rim.

Whatever the origin of the tire may have been, it must soon have become evident that, with its use, the outer segments of the discs making up a three-layer wheel, were now superfluous. Leaving them out would produce a wheel of six wide spokes. This wheel would be much lighter and yet with a "hub" wide enough to assure steadiness. That such was the origin of the spoked wheel is conjecture, yet not without some historic basis. Certainly it is significant that Egyptian wheels and their descendants have either four or six spokes or multiples of four or six. In rural sections of South Carolina there are still to be seen home made carts with wheels of the three-board variety. This wheel is surely not a direct descendant of primitive man's wheel but was doubtless thought out independently by ingenious mechanics forced to make their own wheels.

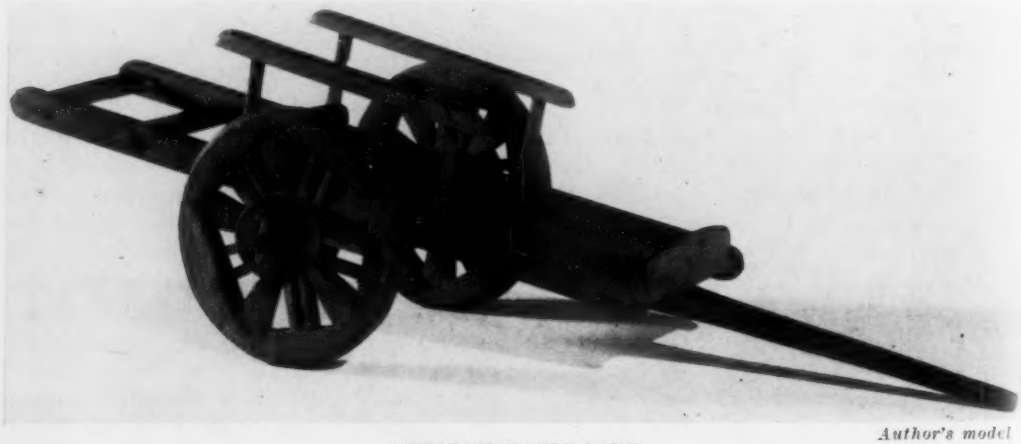
Three boards overlapping at 60-degree angles form six spokes, but the ends of these spokes are not in alignment unless warped into line, which has its disadvantages. But six independent spokes can be aligned. That may be done by constructing the hub separately so that the spokes radiate from hub to rim. Once the trick of putting spokes into the hub had been mastered, the number of spokes could be increased without disturbing the symmetry and balance of the wheel. Thus the way was opened for further evo-

lution of the wheel. This principle of wheel making has stood the test of time and while refinements have been added to the wheel's lightness and strength and general efficiency, no radical change in the wheel has been made for perhaps 4000 years, with perhaps the single exception of the bicycle wheel. In the ordinary wheel the load carried by the axle rests primarily on the spoke directly beneath it and partially on the spokes to either side of it. To be sure, a well-constructed wheel is a single unit in which all parts function at all times, but the weight is mostly a downward push. In the bicycle wheel, however, the load at the hub is suspended from the spokes above the hub. In fact, none of the spokes is completely "idle" at any time, for the rim is somewhat flexible, and a given spoke exerts varying degrees of "push" and "pull" according to the position of the wheel. In principle it is like an arch bridge, the upper part of the bicycle wheel rim being the equivalent of the arch. Instead of steel spokes, flexible cords might just as well be used, though such a wheel would lack steadiness. The lightness of the bicycle wheel makes for easy maneuverability and is peculiarly adapted for a self-propelled vehicle where every surplus ounce of weight and every bit of friction counts.

Another refinement of the modern wheel is the roller bearing. But this represents simply a means of overcoming friction between axle and hub. The pneumatic rubber tire is an innovation (as history is measured) and has made modern motor travel possible. Aside from a few such refinements, the wheel has remained unchanged for many centuries.

The Egyptians carried the spoked wheel to a high degree of perfection. Pictures of their chariots abound, but they do not satisfactorily depict the mechanical principles. Fortunately a few original chariots have been preserved; one from the era of the Ptolemys is in the Florentine Museum. Apparently chariots were used primarily for war purposes and for racing. Consequently they were made light and durable and were drawn by horses. There is little evidence of the use of the spoked wheel for domestic purposes in ancient Egypt, for their roads were designed for foot travel and beasts of burden. The Greeks added little if anything to the wheel, but they did make their chariots of metal and decorated them, sometimes profusely. Like the Egyptians they used the chariot primarily for war and for racing, a very important part of Greek life.

From the Greeks the wheel passed to the Romans unchanged. Roman chariot racing is familiar to every school boy, and Roman roads have become a byword of enterprise and durability. But the Romans extended the use of the wheel enormously. The great contribution of Roman engineers was the discovery of the method of swiveling the front axle. Four-wheeled vehicles had been used by the Greeks, but they were awkward because the front wheels were kept as rigid as the hind wheels, and turning corners meant wasteful skidding of wheels to say nothing of the strain of the side thrust on



Author's model

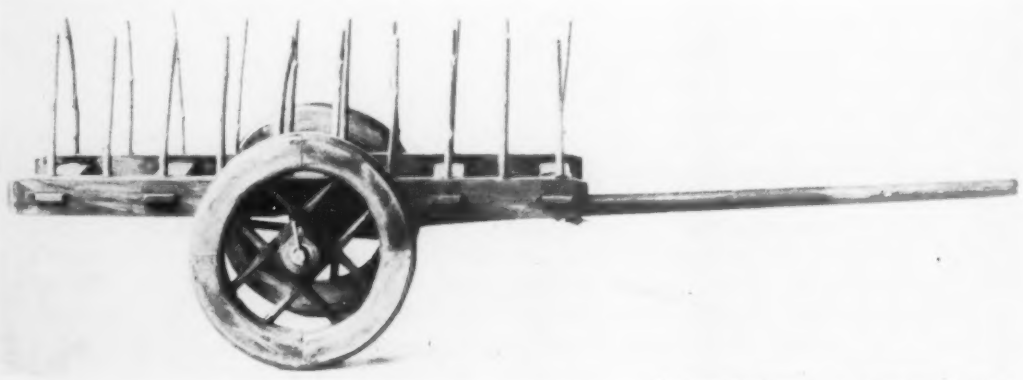
PERSIAN FARM CART

them. Pivoting the front axle opened the way for larger, more commodious vehicles and greatly stimulated passenger use of vehicles. Unlike roads of previous civilizations, those that led to Rome were made primarily for peacetime traffic. Roman travelers were familiar with the rheda, a kind of omnibus or stage, and of private vehicles there were many. The Romans also used the horse for domestic vehicles which, too, was an innovation.

With the fall of Rome the spoked wheel all but disappeared from the Western world, incredible as that may seem. The crude disc wheel was again the only type employed, and for hundreds of years nothing better was at hand. Roads were practically nonexistent, and the chief use made of wagons during the early Christian centuries was for the transportation of the hordes of Gauls and Germans in their great migrations. Goods and chattels of the wandering tribes were carried in huge wagons drawn by oxen, and when the going was difficult, women, children, and the sick rode on them too. At night the wagons provided shelter. They were in effect like the covered wagons of the American pioneers. Wagons of this kind were also used in the numerous wars of that period. By placing them end to end an effective wall of protection, or fortress, was built.

The lowly ox was the draft animal of the early Middle Ages. No one thought of humbling the pride of the stately horse by hitching him to a cart or wagon. He was considered to be a beast fit only for battle and for bearing on his proud back kings and noblemen. But in the twelfth century this sentiment changed, and men began to use the horse for pulling purposes. The horse is a quicker, more responsive animal than the lumbering ox, and the wagons of that day were not geared up to him. So the growing custom of using the horse for draft purposes necessitated refinements and improvements in wagon construction. Slowly, laboriously the spoked wheel was reinvented, or rather reintroduced, for memories and remnants of the wheel of a destroyed civilization must

Photograph from U. S. National Museum
CHINESE CHARIOT



Photograph from U. S. National Museum
EAST INDIAN VILLAGE CART

Photograph from U. S. National Museum

A ONE-HOSS SHAY

have remained here and there. So far-reaching was the effect of this new use of the horse that it may be said to mark an epoch in land transportation, particularly in the development of the spoked wheel. Soon the trade of wheelwright attained high dignity and became one of the most technical and honored of the crafts.

As craftsmen became more skillful and the demands for more rapid transport increased, lighter and stronger wheels were perfected. Much argument and debate ensued as to the size, shape, and dimensions that a wheel intended for a given purpose should have. Methods of fastening the fellies and spokes and of inserting the spokes into the hub were hotly discussed. The number of spokes that a wheel should have was a grave question, and whether or not a wheel should be "dished," and how much, was a serious engineering problem. The iron tire greatly improved the wheel as did also the metal lining inside the hub.

No one has better expressed the spirit of the craftsman than Holmes in the delightful story of "The Deacon's Masterpiece" which begins with the rollicking lines:

> Have you heard of the wonderful one-hoss shay
> That was built in such a logical way,
> It ran a hundred years to a day
> And then, of a sudden it—ah, but stay—

The deacon had noticed that "a chaise *breaks* down but doesn't *wear* out," so he set out to build one that would not break down, by the simple expedient of making "the weakest place as strong as the rest."

> The deacon inquired of the village folk
> Where he could find the strongest oak
> That couldn't be split nor bent nor broke.

He searched out "steel of the finest, bright and blue," while the leather parts came "from tough old hide, found in the vat when the tanner died." Long did that chaise serve the deacon and his children and never a repair was needed until one day, after a century of usefulness:

> It went to pieces all at once,
> All at once, and nothing first,
> Just as bubbles do when they burst.

A fine example of the wheelwright's art!

ECONOMIC ENTOMOLOGY IN SOUTH AMERICA

By EDSON J. HAMBLETON

THE tropics of South America offer almost every conceivable type of ecological habitat: from torrid jungles to snow-covered mountain ranges and from the arid desert land to swampy flood plains. The flora and fauna of these regions are more interesting and by far more complex than those of the temperate zones. For the insect collector and taxonomist the Neotropical fauna has long been the source of much attraction. It is in the tropics or subtropics where size, color, and morphological structure of insects reach their extremes. Many of the classical species of early systematists were specimens taken in the tropics. But despite this interest, so manifest ever since the time of Linnaeus and Fabricius, entomologists now working in the tropics are constantly confronted with innumerable problems related to the identification of the common insect fauna. Many of the described species from South America that are located in European museums are inaccessible and of somewhat doubtful status owing to changes in present-day methods of study. This situation will gradually tend to improve. For example, increased interest in biological sciences has been notably demonstrated in Brazil by the appearance of new journals and scientific publications during the last fifteen years. Agricultural colleges and universities are improving their teaching staffs while an ever-increasing number of students seek courses in or related to zoology and entomology.

Many outstanding contributions to medical entomology and parasitology have been made in South America since the beginning of the present century. Men like Oswaldo Cruz, Adolpho Lutz, Arturo Neiva, and Costa Lima have long been the source of much inspiration to their fellow workers and students throughout Brazil. Entomological problems relating to health and sanitation, insect disease vectors, and systematic and biological work on various families of disease transmitting species have occupied the attention of the leading scientists in the country. But not until about the year 1924 was any particular emphasis given to insect pests of agricultural importance except for the ubiquitous leaf-cutting ants and other insects affecting fruits and vegetables. Coffee, sugar cane, and cotton (three of the leading crops) until that time had received little entomological attention. Nearly one-half of all entomological contributions up until 1924 concerned insect taxonomy and medical entomology. During 1924 and the following years, numerous publications appeared relating to the coffee berry borer, *Stephanoderes hampei*, an imported species introduced in coffee seed from Java several years prior to that time.

Economic entomology seems to have gained a sudden impetus through the ravages of the berry borer in the State of São Paulo, Brazil. From the activities of a Commission appointed to formulate ways and means of studying and controlling the pest, there resulted the development of the *Instituto Biologico de São Paulo*, today one of the best-known scientific institutions in the country.

In spite of all efforts on the part of the Federal government and the State of São Paulo to check the spread of the coffee berry borer, the insect continued its destructive march into the richest coffee growing areas of the State. By 1929, losses were mounting to such an extent that many growers began to abandon their plantations. This resulted in an increase of the pest at a time when market conditions were at their worst. Control measures by fumigation and clean cultivation became financially impossible, and a crisis developed. During the ensuing years the stock of coffee in government warehouses became a drug on the market. Growers were face to face with a situation never before encountered in the history of coffee production. In the severely infested areas the cost of production had naturally increased owing to reduced yields of an inferior product and to the growers' obliga-

tion to fumigate their entire stock and conduct clean-up measures in their plantations after harvest. Government regulations made it imperative that abandoned coffee trees be removed since these served as a constant source of infestation.

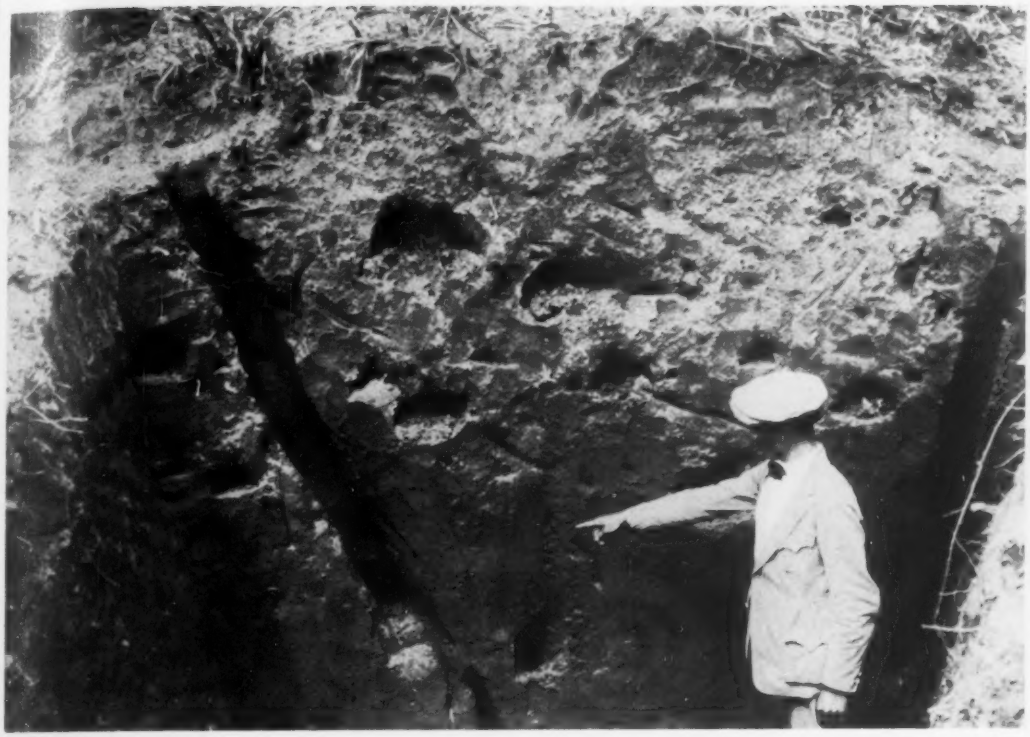
Thus the problem of the coffee berry borer confronting the São Paulo coffee grower became more complex. The majority of these growers in the stricken area had not previously experienced the difficulties involved in insect control, for coffee, their chief crop, had suffered little or no damage of economic importance from other insect enemies. The less fortunate growers went bankrupt; others chose the path of least resistance, decided to abandon coffee cultivation altogether and pursue what then appeared to be a more lucrative system of agriculture never before attempted in their particular localities.

From coffee, many turned to cotton cultivation; while corn and various other crops found their way into an ideal form of crop rotation which had not been feasible under the one-crop system, in operation since colonial days.

The eradication of many million bearing and abandoned coffee trees literally revolutionized agricultural practices. Throughout this area the berry borer infestation diminished considerably, and those who survived the crisis and continued to grow coffee were soon convinced that practical control measures were effective in maintaining the borer infestation at a minimum.

For twenty years the coffee berry borer gradually extended its range in all directions, and today there remain but few areas in the State of São Paulo where it is not present to some extent. In the southwestern portion of Minas Geraes, the borer invaded coffee plantations as early as 1932. However, it has not constituted as serious a menace there as in São Paulo, nor has it been able to spread to other more remote coffee producing areas in the State, owing primarily to the nature of agricultural practices, local topography, and shipping restrictions.

A NEST OF THE LEAF-CUTTING ANT, *ATTA SEXDENS RUBROPILOSA*
PARTIAL VIEW SHOWING LOOSE EARTH AND NUMEROUS ENTRANCES IMMEDIATELY ABOVE THE OCCUPIED AREA.



CROSS SECTION OF NEST AFTER EXTERMINATING COLONY WITH CARBON DISULPHIDE
AN EXCAVATION OF THE NEST SEEN IN THE PREVIOUS ILLUSTRATION SHOWS THE REMAINS OF THE FUNGUS GARDENS IN THE LARGER CHAMBERS. THE TWO OBLIQUE CHANNELS WERE MADE FOR APPLYING THE FUMIGANT.

The coffee berry borer control program developed into the most important entomological project in Brazil. From the time of its inception, much emphasis has been given to biological control following the introduction and large scale production of the natural enemy, *Prorops nasuta*, from the Uganda Protectorate in 1929. This hymenopterous parasite readily adapted itself to São Paulo conditions and after a few years was established in several areas of the State. Fumigation of infested fruits at harvest time and the "clean-up" or removal of fallen berries and those overlooked in the trees at picking time are still considered of paramount importance in the control program.

When it was once confirmed that the parasite population had shown indications of increasing under field conditions, there soon developed a widespread demand for the parasite. Consequently, small colonies were distributed among growers as fast as they became available. Small rearing units were established on individual fazendas where necessary instructions were issued to growers to facilitate the rearing and liberation of their own parasites. Facilities for higher production were developed at the Instituto Biologico in Campinas, and this organization co-operated in the distribution and instructional work to such an extent that today parasite activity may be observed on practically all the infested plantations in the State.

Irrespective of all the effort exerted and of eagerness on the part of coffee growers to succeed in this new undertaking, no very concise conclusion has yet been reached as to the actual benefit derived from the parasite. This is due to a number of other factors, any one of which may have been partly responsible for decline in infestations of the berry borer. Parasite populations as a rule generally increase or decrease according to the density of the host population. This holds true for *Prorops nasuta* under São Paulo conditions. Climatic conditions

COFFEE TREES JUST BEFORE HARVESTING
ALL VEGETATION AND TRASH ARE REMOVED AND THE SOIL SMOOTHED OFF BEFORE GATHERING THE BERRIES.

and the time and nature of the harvest vary considerably from one zone to another throughout the vast coffee growing area of the State. The activity of the parasite may be interrupted at harvest time when conditions for its propagation are conducive to a rapid increase in population. The fumigation of the berries at picking time is followed by an obligatory clean-up throughout the groves to eliminate any remaining berries that may harbor the coffee berry borer through the winter season. Incidentally, the Uganda wasp is entirely dependent on the berry borer for its survival and the number of wasps gradually diminishes as its food supply runs short.

In order to carry the wasp through the winter season, it is absolutely essential that borer-infested fruits be accessible at all times. This is accomplished by placing infested fruits, with or without parasites, in small screened insectaries where sufficient heat is provided for reproduction. Otherwise the adult parasites, like those in the field during the winter, practically cease to oviposit and act as predators as long as weather permits.

In some areas of the State the parasite will probably be found more effective than in others. But despite any doubt that may still exist as to its usefulness, the parasite program has gained much prestige in agricultural circles. It has done much to foster the promotion of further interest in applied entomology in Brazil.

Cotton is one of the oldest and most important of all crops grown throughout the northeastern states of Brazil where it constitutes the chief source of income over a very extensive area comprising the larger portion of the States of Pernambuco, Parahyba, and Rio Grande do Norte. Although the climate, topography, and fauna of these three states are much alike, in each there are quite distinct areas in which conditions vary considerably and the problems confronting the growers are indeed complex. Several kinds of cotton are grown. Some localities where rainfall is more abundant

are suitable for the herbaceous varieties, whereas in the more arid or semiarid areas only the perennial cottons are cultivated. Where rainfall is plentiful, insect enemies are likewise more troublesome. Some of the same insect pests occur in the perennial cotton grown in the more arid regions, but damage there is less severe. The plantings are usually small and often widely separated and are located where soil moisture is most abundant. Control of some insects is obtained by the simple cultural methods where insecticide applications are not often satisfactory.

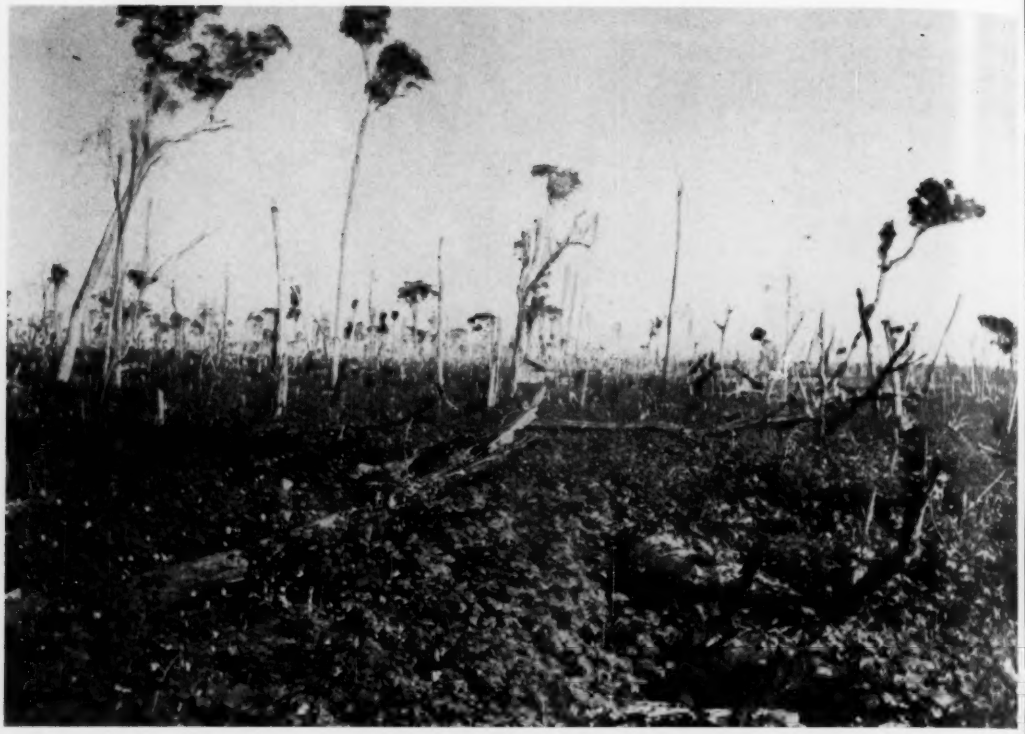
The cotton borer, *Gasterocercodes brasiliensis*, may be found throughout most of the cotton growing areas in Brazil. In the north it is a pest of both annual and perennial cottons but causes more severe loss to the herbaceous varieties grown where temperature, rainfall, and soil conditions are more favorable to its propagation. But even in the more arid regions this species has a general distribution and despite less favorable conditions it is present to some extent in practically every planting of perennial cotton. Because rainfall through the Sertao (semiarid region) is very irregular over a period of years, cotton seed must be planted immediately following the heavy rains that may come no oftener than once in several years. The cotton borer is readily attracted to new plantings and thus inflicts severe damage during the first season's growth. To insure against total loss, the fields are heavily seeded, and thinning is delayed just as long as possible. If the grower is successful in maintaining his plants during their first season, neither drought nor borer attack are likely to cause him much further concern. If given a chance, the plants develop rapidly and for several years will usually tolerate both insect attack and scanty rainfall. Four- or five-year-old cotton plantings are seldom free from borer injury. At this age their branches usually become so infested that they are easily broken, and such plants can no longer be cultivated economically. In the areas where rainfall is plentiful, as in parts of Pernambuco, Bahia, and farther south in Minas Geraes and São Paulo, the cotton borer often occasions serious losses early in the growing season. In these areas only the herbaceous cotton is cultivated. Being less resistant to attack, it must be thinned early and it more often succumbs to borer attack. Here again cultural control methods are practiced and, where conducted systematically over a wide area, generally prove quite effective.

In recent years, some attempts have been made to control the cotton borer by means of

INFESTED COTTON FIELD

UPLAND COTTON IN SÃO PAULO INFESTED WITH THE COTTON ROOT BORER, *Gasterocercodes brasiliensis*.

COFFEE BERRIES



COTTON GRADUALLY DOMINATES AS FOREST LAND GIVES WAY TO MODERN AGRICULTURE
THIS IS A TYPICAL SCENE IN A WOODED AREA IN NORTHWESTERN SÃO PAULO, 1938. THE LAND HAS BEEN CLEARED AND ALL BUT THE BEST TIMBER HAS BEEN FELLED AND BURNED AND THE SOIL PLANTED TO COTTON.

arsenical sprays with a reasonable degree of success. Control of this insect with poison dusts or sprays has not been universally adopted on account of the expense involved and the difficulty of making effective treatments during the rainy growing season.

A closely related species, *Gasterocercodes gossypii*, occurs in Peru and Ecuador. Legislation which prohibits the cultivation of ratoon cotton and limits the period during which plants may remain in the field has proved very successful for the control of this insect in northern Peru.

The cotton leafworm, *Alabama argillacea*, is the best-known pest of cotton in Brazil. It has always been a constant menace, appearing each season at more or less the same time in any particular region. Propagation of this species is rapid, and within a short period infestation is widespread. During adverse weather cotton growers are seriously handicapped in applying arsenical sprays. The leafworm infestation coincides with the rainy season, and anyone who has ever undertaken insect control during prolonged rainy spells can readily appreciate what the Brazilian cotton grower must contend with in protecting his crop. All spraying is done by hand because power sprayers cannot be operated on hilly terrain and on wet soil. Hand labor is also considered more economical where it is readily available. Large growers must necessarily be well stocked with hand sprayers, prepared to make an application at a moment's notice, or to repeat an application as occasion may demand.

In Brazil the leafworm is attacked by a host of natural enemies, including both ecto- and endo-parasites, insect predators, and birds. But only after much damage has occurred and the temperature subsides is one able to appreciate the role they play in natural control.

In Peru the cotton leafworm problem is quite distinct. Moths invariably invade the valleys in the northern provinces and are especially troublesome in the Chira and Piura valleys. The bulk of the cotton crop

is grown in approximately thirty valleys extending along the coast almost as far south as the Chilean border, but only upon rare occasions is the insect ever observed south of Lima. Consequently, it is not considered of any importance elsewhere in the country. It has always been somewhat of a mystery why the insect has confined its activity to the valleys in the north. Although most of the valleys are small and separated by wide extensions of desert land, such factors would hardly explain its absence farther south. Climatic conditions vary considerably in the different cotton-growing valleys where rainfall is negligible. But here again such differences as temperature and relative humidity would not seem to be of sufficiently great importance to limit the insect to its present destructive range. The climate along the coast is subtropical, the winter season being rather humid, while the summers are very dry. In the Chira and Piura valleys to the north the cotton crop is usually harvested before planting gets under way in the Rimac valley at Lima and at Canete, some 160 kilometers farther south. In other words, there appears to be but slight possibility that moths of *Alabama argillacea* would migrate south to any great distance from Piura at a time of year when mean temperatures average about 60 degrees F. at Lima and Canete and before cotton is suitable for attack. Other atmospheric conditions resulting from the effects of the Humboldt current, such as the formation of dense clouds that cover the coastal lowlands during the winter months, may exert some influence as barriers against migrating moths. The Andes Mountains to the east also serve as important barriers.

Another South American insect of world-wide distribution and long considered one of the most important pests of cotton is the pink bollworm, *Pectinophora gossypiella*. Since first reported in Brazil, this insect has extended its range to include all of the more important cotton growing areas in the country. Annual losses have never been satisfactorily calculated inasmuch as they vary greatly from one area to another and in the different varieties cultivated. In the herbaceous or Upland cottons grown in areas of favorable climatic conditions, the damage is exceedingly high. Losses seem to be even more severe in seasons of excessive rainfall as observed in the State of São Paulo. Aside from the destruction of seed and fiber, con-

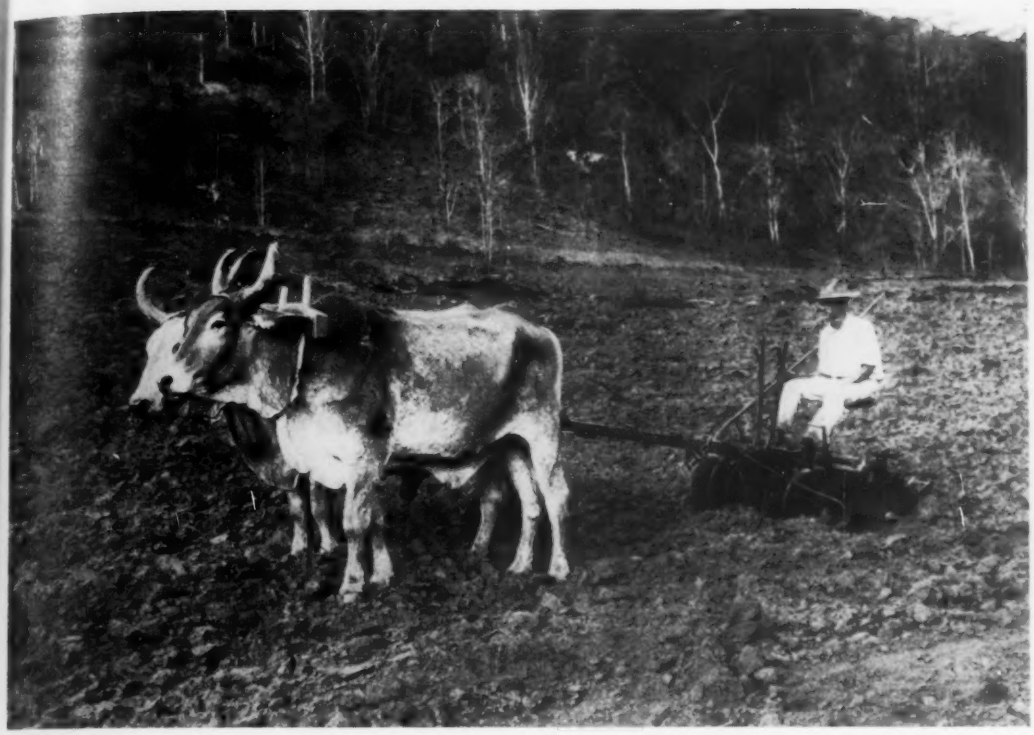
CREWS OF LABORERS SPRAYING COTTON WITH KNAP SACK SPRAYERS
PRACTICALLY ALL SPRAYING IS BY HAND. HERE IT HELPS TO CONTROL THE LEAFWORM, *Alabama argillacea*.

DEFOLIATION BY THE COTTON LEAFWORM, *ALABAMA ARGILLACEA*
ALTHOUGH EARLY DAMAGE REDUCES YIELD, LATER DEFOLIATION SOMETIMES AIDS IN HARVESTING THE CROP.

siderable loss is occasioned through shedding of squares infested with pink bollworm larvae early in the season before bolls are far enough developed to be attractive to the egg-laying moths.

No organized campaign to control the pink bollworm has ever been attempted in Brazil. Indeed, if such an undertaking were to evolve, it would require a large corps of field inspectors to contact growers, to visit fields that extend through most of the cultivated farming areas of the country, and to maintain vigilance at cotton gins, oil mills, and storage houses. In fact, a venture of this nature would have to include the co-operative efforts of practically everyone connected with the cotton industry. Perhaps the most difficult task would be the clean-up and destruction of crop remains after harvest. On a few of the larger estates this type of control is practiced, but as a rule no effort is made among the thousands of smaller growers to do more than burn the stalks some time after the cotton is picked. Since it has been estimated that roughly 90 to 95 per cent of the infestation originates from bollworm moths that have emerged from crop refuse left in the field, clean-up measures are of the most vital importance in any kind of a control program to suppress the pink bollworm in Brazil.

Perhaps too much value and "wishful thinking" has been placed on seed fumigation as a means of pink bollworm control in preventing its spread into newly developed cotton growing areas in São Paulo. It is rather unfortunate that this general opinion has so long prevailed, for regardless of the fact that all cotton seed has been controlled and fumigated by the State for several years, not a single area is free from the insect. Seed fumigation does, nevertheless, have its place in the control program, but it alone cannot control the bollworm nor reduce to any appreciable extent the amount of damage it annually causes. Unless other measures are adopted, losses are more than likely to increase over a period of years, depending to some extent upon the acreage under cultivation, crop rotation, etc.



ZEBUS PULLING A DISC AT THE AGRICULTURAL COLLEGE IN VIÇOSA, MINAS GERAES
ALTHOUGH MODERN TRACTORS ARE COMMON IN BRAZIL, OXEN STILL DO MUCH OF THE AGRICULTURAL WORK.

The present status of the pink bollworm in other Brazilian states is nearly identical, particularly where rainfall is plentiful. The exception occurs in the semiarid regions of the northeast where excessive daily temperatures often range as high as 100 degrees F., and where extended periods of drought accompanied by high winds exert much influence on insect survival. Under these conditions, the pink bollworm may be observed over an extensive desert-like region causing a regular amount of loss annually, but never is it very serious except in isolated locations during years of rainfall.

Pectinophora gossypiella has never been known to occur in Peru. This country is one of the few, if not the only one, producing cotton that has not had to contend with the insect, aside from exercising every precaution at port-of-entry to exclude its introduction. Some fear has been expressed that it may gain entrance from Ecuador or over the Andes from the Amazon valley by commercial transport from those regions.

Since the crisis of 1929 agricultural development in São Paulo has made rapid strides towards a more efficient utilization of the soil in the diversification of crops. Up until 1930 the coffee crop represented approximately 70 per cent of the total value of exported products. In 1940 this had fallen to 32 per cent. Cotton became the chief competitor; the total acreage of this commodity was almost equivalent to that of coffee. Corn, rice, beans, cassava, castor beans, and citrus fruits ranked next in their respective order as to acreage. Along with this phenomenal change, industrial output increased and, during the same year, its value was two and one-half times greater than that of agricultural products.

Diversified agriculture has thus become thoroughly established in a land where almost every kind of crop may be grown. Indeed, it would not seem too premature to believe that, along with all the complications involved in a changing agriculture, the part that insects and diseases will play will gradually reach greater proportions as time passes. The cotton plant has long been

known as one of the most attractive of all cultivated plants to insect pests wherever it is grown. In areas where this or any other crop is cultivated on a large scale for the first time, insect pests gradually move in and, if undisturbed, may often become established and in due course of time actually menace the crop. Such is the case of the plant bug, *Horcius nobilellus*, in São Paulo, today ranking among the most destructive cotton pests in the State. Not only do the injurious species take advantage of improved conditions for obtaining food and propagate more rapidly, but so do their natural enemies. Some of these may, after a time, tend to hold certain obnoxious forms in check. The abundance of either the injurious or beneficial forms is greatly affected by seasonal differences in temperature and rainfall. The grower must necessarily experience all these risks and in doing so he soon learns that some insects will cease to be troublesome under certain conditions.

Insect control in the tropics is not as simple as it sometimes appears. Spraying and dusting equipment is expensive and not very durable. In most countries both equipment and insecticides have to be imported. Such products are not always readily available or even accessible to the small producer who seldom cares to invest his meager savings in something he thinks is of doubtful value. Usually the common practice of abandoning a crop in favor of a substitute occurs when insects or other unfavorable factors are causing destruction. If land is cheap and the soil fertile, this method may prove the most economical in the long run. Another practice is to plant more than is necessary on the assumption that a certain percentage will be lost through ravages of one kind or another. Perfectly good farms have been abandoned on account of the leaf-cutting ant, *Atta sexdens*, and related species, because growers either lacked information on their control or found that the expense in combating them was more than they could meet. These ants are native to the tropics, abound in all sorts of locations, and are a constant annoyance to man by attacking many kinds of crops. In Brazil they are considered the most destructive species to agriculture. Even though successful methods have been devised for their control, hundreds of thousands of their colonies will long constitute a veritable menace and require constant attention.

Investigational work on insecticides has not yet received much attention in the majority of entomological institutions largely because there has been no urgent demand for this type of research. As field work on insect biology and control expand, one should expect a corresponding development with insecticides. Possibly the present interest in the production of pyrethrum and rotenone-bearing plants in Latin America will stimulate further interest in this field and encourage the use of new insecticides there.

The application of insecticidal products has been confined almost exclusively to cotton in the form of lead and calcium arsenates and to citrus as oil emulsions. Fumigants, principally carbon disulphide, are used to disinfest coffee and cotton seed and to exterminate leaf-cutting ants. Sulphur and arsenic fumes are employed against ants, and calcium cyanide (hydrocyanic acid gas) is used to some extent against citrus pests and ants. A considerable number of other preparations are on the market, but their use is not very general. Until recently mechanical control of locusts (grasshoppers) had been the most dependable, but not entirely satisfactory, means of controlling these insects in several South American countries. Such methods, however, are rapidly giving way to new discoveries, chief among which has been the application of a dust, containing 3:5-dinitro-o-cresol, by airplane and by hand and power dusters. This development has brought much encouragement to areas where locust plagues occur. Its remarkable success in Argentina should not only prompt its adoption in other South and Central American countries where these insects prevail, but also new possibilities for its application may result against such pests as the Dysdercus cotton stainers and others heretofore not easily controlled.

THE PRINCIPLE OF THE UNOBSERVABLE

By H. M. DADOURIAN

FROM Galileo to Einstein, the physicist went about his researches as if he believed in the principle: *that which is unobservable is not significant.* He did not formulate this principle, however, or consciously make use of it. But because he was looking for observables, he generally avoided unobservables.

Einstein was probably the first physicist to recognize the value of the principle and to use it consciously. He stated it, in connection with the concept of the simultaneity, in the following terms:

> The concept does not exist for the physicist until he has the possibility of discovering whether or not it is fulfilled in an actual case. . . . As long as this requirement is not satisfied, I allow myself to be deceived as a physicist (and of course the same applies if I am not a physicist), when I imagine that I am able to attach a meaning to the statement of simultaneity.

In a very stimulating article, Herbert Dingle points out that this statement of Einstein has been acclaimed as a great discovery by some physicists and philosophers, while it has been condemned as pure nonsense by other physicists and philosophers. Dingle ascribes this divergence of opinion to the fact that the concept of the unobservable has not been analyzed and clearly defined. He analyzes the concept and from it draws some startling conclusions. He classifies unobservables under three heads: the *logically,* the *physically,* and the *practically* unobservable. The logically unobservable is that which violates laws of reason. The physically unobservable is that which cannot be observed by any possible means of observation. The practically unobservable is that which cannot be observed by any known means of observation, but could be observed if these means were refined and perfected to the theoretical limits of their possibilities.

But, according to Dingle, if we assert that something is physically unobservable, while believing in the existence of the external world, we should be assuming that we know all the possible means of observing it. That would be tantamount to presuming omniscience. Dingle concludes, therefore, that we face the dilemma of giving up either the principle of the unobservable or the belief in the external world.

Dingle would retain the principle and give up the belief. For if the principle were abandoned there would be no check to empty speculation and idle invention. As an illustration of what might happen, he says:

> Suppose, for example, I assert that there is a binkum sitting on the table in front of me, and that this tremendous fact, rightly understood, is the final, completely satisfying solution of the problem of evil. If you reject the principle in question, you have no grounds for denying the statement. You may say that you cannot detect my binkum, but I reply that of course you cannot, because he is unobservable. If you want to know how his existence solves the problem of evil, I say that it is its nature to do so, and the definition of him, according to your own contention, is quite independent of any means you adopt to investigate him . . . . Stupid as this example sounds, it contains a precise parallel to the case of simultaneity.

Dingle is thus led to the conclusion that we must give up the belief in the external world and adopt the idealistic view. In the article he does not state what he means by the 'idealistic view.' This he does, however, in his book *Through Science to Philosophy.* His comments on the following quotation from Eddington's *The Nature of the Physical World* shows clearly that his idealistic view is indistinguishable from solipsism:

> The only subject presented to me for study is the content of my consciousness. You are able to communicate to me part of the content of your consciousness which thereby becomes accessible to my own. For reasons which are generally admitted, though I should not like to have to prove that they are conclusive, I grant your consciousness equal status with my own.

Dingle says: "It is clear that there is an inconsistency because other person's consciousness is said to be partly in his own and yet to have equal status with it." Commenting further on Eddington's idealism he continues:

> . . . to say that solipsism is logically irrefutable is to express the fact too mildly. It is not merely irrefutable; it is absolutely true . . . . The real problem is having admitted the necessity of solipsism as a

starting-point, to proceed from it to give a satisfactory interpretation to experience as we know it. . . . He is too honest to obscure the fact that solipsism is the logical starting-point, but instead of starting from it he jumps a gap, for reasons which he would not like to have to prove were conclusive, and sets out with obviously incompatible consciousnesses forced to an impossible equivalence.

It seems to me that both Eddington and Dingle are stating self-contradictory propositions. For if I were a solipsist, you would have existence to me only by virtue of being a part of my consciousness; consequently whatever you communicate to me would be a part of a consciousness which is a part of my consciousness, which makes no sense. Besides, what meaning could I then attach to the word communication?

Whether I grant your consciousness an equal or inferior status with mine, you could not successfully challenge any binkum which I may invent, because the challenge would be from a part of my consciousness to another part. It appears therefore that by adopting solipsism in order to exclude binkums, Dingle opens the door wide to them to come in.

Furthermore, if I proceed from solipsism as a starting-point what would happen? In the process everything external to "myself" would vanish first into nonexistence; then my own body would disappear with the rest of the nonexistent, unreal world; even my past would follow suit. Thus the "real" world would reduce to the momentary "I," the epitome of my consciousness of the present moment. As time passes, the "I" which was real at one moment would merge continuously into the limbo of the vanishing external world, and a new real "I" would appear in its place. Thus, in Minkowski's space-time diagram, there would be only one point-event, the one that represents the ever-present "I."

Therefore if I proceed from solipsism as a starting-point, I finally arrive at the purest stage of solipsism where there are neither observables nor unobservables; consequently the principle which Dingle is rightly anxious to preserve becomes a collection of meaningless words. At that stage science and philosophy, in fact all human activities, lose significance and meaning.

So far the argument stands as follows: Because of its usefulness, the principle of the unobservable should be retained if possible. But if we accept the principle, while believing in the external world, we place ourselves in the untenable position of presuming omniscience. On the other hand, if we renounce the belief in the external world and adopt solipsism, we not only reduce the principle to a meaningless jargon but also get involved in endless logical absurdities.

Dingle has made a real contribution by analyzing the concept of the unobservable, by formulating the principle of the unobservable, and by stressing its importance. But he has drawn unsound conclusions from his analysis as a result of adopting unscientific definitions for the three classes of unobservables. Dingle's dilemma is of his own making and springs from his definitions, as may be shown from a consideration of the following quotation:

Let us suppose that we have discovered all the means of observation that exist in the universe, and know all their properties completely. We might then be able to imagine other means of observation which do not exist. Anything which would be observable by such imaginary means, but not by existing means, would be *physically* unobservable. Anything which would be unobservable by *any* means, existing or imaginable, would be *logically* unobservable. Anything which would be observable by the existing means if we were also omnipotent, but which is actually unobservable because we cannot make full use of the means of observation which exist, would be *practically* unobservable . . . . If we assume that we are omniscient we can distinguish three classes—the *practically*, the *physically* and the *logically* unobservable. If we do not assume that we are omniscient we can distinguish only two classes—the *actually* and the *logically* unobservable, let us call them.

By adopting definitions in terms of omniscience and omnipotence Dingle falls victim to the kind of fallacy involved in dividing two members by infinity and then equating the results to prove that two unequal numbers are equal. These definitions are not scientific definitions in that they do not specify practical criteria by means of which the concepts defined could be distinguished from other concepts. The following definitions are not subject to these criticisms:

Anything is logically unobservable if its definition is incompatible with the laws of logic or necessarily contains logical circularities.

Anything is physically unobservable if its observation calls for means which are incompatible with established facts and principles.

Anything is practically unobservable if its observation calls for means which are not available but which are compatible with established facts and principles.

These definitions enable us to distinguish among the three classes of unobservables without any presumption of omniscience or omnipotence. Thus we avoid Dingle's dilemma of having to give up either the principle of the unobservable or the belief in an external world.

The word 'unobservable' is used here as a scientific technical term. In the ordinary sense of the word it should have no place in the first definition because the question of the validity of a logically unobservable could be determined without resort to observation. In the third definition, it is clear that the 'practically unobservable' is the '*potentially* observable,' which would be a better name for it. Evidently the principle of the unobservable applies only to the first two classes; therefore it may be put in the following more specific form:

That which is logically or physically unobservable is not significant.

Whether a concept belongs to the class of the logically or the physically unobservable may depend on tacit assumptions on the basis of which the concept is defined. This is the case with the concept of simultaneity. The following examples illustrate the application of the principle.

Absolute simultaneity. If we grant the velocity of light to be the greatest velocity of communication, the simultaneity of two distant events becomes logically unobservable because its definition would necessarily involve, as Einstein has shown, the concept of synchronous clocks which in turn would involve the concept of simultaneity; in other words, the definition would contain logical circularity.

On the other hand, if we define simultaneity on the assumption of an infinite velocity of communication, the concept of simultaneity would be logically observable but, according to our definition, it would be physically unobservable because infinite velocity of communication is not compatible with established facts and principles.

The vehement objections raised by the critics of Einstein's statement are partly due to the use of the word 'meaning.' Simultaneity would have a meaning in the ordinary sense of the word on the assumption of an infinite velocity of communication. But it will have no significance until such a velocity of communication is available. Furthermore, the probability of an infinite velocity of communication becoming available is next to nothing, because any communication involves transfer of energy and consequently of mass, and mass moving with infinite velocity requires infinite energy.

Perpetual motion. Perpetual motion of the first type, in which more energy is supposed to be obtained from an engine than is put into it, is logically unobservable because it, in effect, equates two unequal quantities.

Perpetual motion of the second type, in which friction is supposed to be completely eliminated, is physically unobservable because the assumption is not compatible with established facts about friction and physical theories, such as the atomic theory of matter which is based on innumerable facts.

Perpetual motion of the third type, in which all the energy put into an engine is supposed to be recovered as useful work, is also physically unobservable because the assumption is not compatible with established facts and Carnot's principle.

THE GREAT ARYAN MYTH

By KNIGHT DUNLAP

THE Aryan myth is now completely discredited among scholars. Ethnologists (outside of Germany) do not speak of an Aryan race any more than they speak of a Jewish race. Linguists no longer speak of an Aryan family of languages, preferring the less succinct but more accurately descriptive term 'Indo-European.' Popular thought, however, seems still somewhat confused by the word 'Aryan.'

The actual origin of the myth is obscure. Hankins (*The Racial Basis of Civilization*, 1926) traces it back to the early period of the nineteenth century, and if its roots extend further into the past, they are not clearly uncovered. The German warmongers, in the latter part of the century, avidly adopted the myth as dressing for the doctrine sometimes called 'Pan-Germanism': the doctrine of a race of supermen, destined to dominate the world with the ruthlessness of ancient savagery. This doctrine of a great German race, however, is older than the Aryan myth. It was well established before Nietzsche fulminated against morality and humanitarianism. Perhaps the German paranoia can be traced back to Fichte, Schelling, and Hegel, as Hankins implies, and as Kolnai (*The War Against the West*, 1938) seems to think it can be. This possibility is not important for our present purposes. The doctrine of a German race of supermen is certainly older than the Aryan myth.

In its commonest form, the Aryan myth postulated a group of people calling themselves 'Aryans,' who invaded India at some time before the Christian Era and settled in the Indus Valley. Various speculative theories as to the location of the original "home" of these Aryans were invented by scholars who credulously accepted the myth. All the theories agreed, however, that from some place of origin, whether in Europe or Asia, groups of this Aryan stock migrated into India, Iran, and Europe.

If, however, we seek for historical evidence for the existence of this early Aryan stock or for legendary accounts of their migrations and activities, we find that the evidence is nonexistent and that there were no legends about an Aryan racial stock until a century or so ago. The myth is a modern invention.

Many foreign groups have invaded India during the last few thousand years, but there is no reference in Hindu traditions to a group of invading Aryans. There is no reference to such a group in Persian traditions. This is inconvenient for the adherents of the Aryan myth, for although the *Vedas* and the *Avestas* were not written until after the beginning of the Christian Era, they presumably embody legends handed down from earlier periods, or are based on such legends. The word 'Aryan,' and its cognates, appear, it is true, in various writings and inscriptions (see "Aryans," *Encyclop. Brit., Ninth ed.*); but there is no passage or inscription which clearly refers to an Aryan stock or racial group. The word, it is established, means 'noble,' 'illustrious,' or of 'aristocratic lineage.' Only a purblind devotion to a doctrine could twist any of the passages into evidence for an Aryan racial stock.

The myth was the creation of German linguists and philologists, who confused language relationships with racial stock relationships; or who, at least, accepted the former as valid evidence for the latter. We cannot date the origin of the myth earlier than the nineteenth century, because it was not until 1788 that Sir William Jones pointed out that the Greek, Latin, Celtic, French, and Germanic languages had definite affinities with the Sanskrit. In 1808 Friedrich Schlegel declared that Sanskrit was the parent language of the Indo-European group and identified it as the language of a parent Aryan race. Jones' concept of an Indo-European family of related languages was rapidly accepted, and is accepted today, although the 'family' has been rather drastically revised in recent years; but Schlegel's notion that Sanskrit was the original Indo-European language was soon discarded, even by those who gave credence to the myth of an Aryan race.

The myth was developed in Germany during the middle of the nineteenth century by many philologists and literati. Its spread in England and France, and further in America, was greatly promoted by F. Max Müller, a German philologist who became professor of comparative philology in Oxford University. In his lectures before the Royal Institution, in 1861 and 1863, on the *Science of Language* (shortly published under that title) Müller employed the term 'Aryan' for the Indo-European family of languages, and insisted that the various peoples speaking the languages of that family must have had a common ancestry. Somewhat chastened by the critical attacks of anthropologists, archeologists, and the more enlightened philologists, Müller, in 1888, explicitly retracted his doctrine and admitted emphatically that language affinities are not evidence for racial relationships. By this time, however, the impetus which Müller's endorsement had given to the Aryan myth had carried it so far that his retraction could not undo the damage.

Meanwhile, a presentation of the myth which antedated Müller's endorsement had come to the attention of influential Germans. This was the presentation by an obscure Frenchman who had changed his residence to Germany, and who eventually became famous (or infamous) throughout the western world: the Count de Gobineau. De Gobineau had published his *Essai sur l'inégalité des races* in four volumes, in the years 1853–55. In this book he adopted the myth of the ancient Aryan race and attributed superiority to those descendants of the Aryans whose blood was least degraded by mixture with inferior stocks. As to which modern types best represented the original Aryans, de Gobineau seems to have been somewhat uncertain, although he expressed the conviction that the modern Germans are not good representatives and that for the purest descendants of the noble race one would have to look to England where the stock has been better protected by the insularity of Britain.

De Gobineau's *Essai* received little attention for twenty years after its publication, and a second edition did not appear until 1884. The first volume only was eventually translated into English (New York, 1914). In Germany, after the Franco-Prussian War (1870–71), de Gobineau came in contact with Friedrich Nietzsche and Richard Wagner. Nietzsche, the half-Polish proponent of savagery, was apparently much impressed by de Gobineau's ideas; but it was Wagner who gave them publicity through articles in the *Bayreuther Blätter* and brought de Gobineau to the attention of influential persons. Wagner already had the notion of the superiority of the old savage culture of central Europe and its degeneration in modern culture, and was attempting to express this devotion to the dismal past in his music, as Nietzsche did in his pseudophilosophy. Wagner's efforts, it seems, were further stimulated by de Gobineau. Wagner put Gobinism in a conspicuous position, although the *Gobineau Vereinigung* was founded (Leipzic, 1894) after Wagner's death. Houston Stewart Chamberlain, a renegade Englishman, whose writings were influential in France, England, and America in promoting the Aryan myth, was Wagner's disciple and son-in-law.

De Gobineau's suggestion that the English, not the Germans, are the best modern representatives of the Aryans was curiously overlooked or ignored in the spread of Gobinism in Germany. We may surmise (but it is only a surmise) that de Gobineau, after he was taken up by the Germans, soft-pedaled this detail of his theory. At any rate, the doctrine that the Germans are the great Aryans, destined to suppress the decadent humanitarianism represented by Christianity and by ruthless savagery to enslave and rule the non-Aryan nations, became practically the state religion of Germany. This doctrine began to be impressed on the German population very soon, and by 1914 the war lords found it a useful factor in building morale in the first war against civilization. We can understand the avidity with which the warmongers adopted the Aryan myth as an adjunct to Pan-Germanism as well as we can understand Hitler's partiality for the music of Richard Wagner.

The Aryan myth has been relegated to the files of astonishing superstitions, and with it has gone the Max Müllerism (as Reinach called it) which naïvely assumed that language affinities are dependable indexes of

stock relationships. On the other hand, it must not be concluded that the theory that certain patterns of mental abilities and attitudes go with certain racial stocks is now scientifically discredited. Those who assume that there are no mental differences correlated with racial stock differences are speaking from armchairs which are not far from the seats of those who broadcast the claims for the inherent superiority of this race or that. There is no foundation at present for either extreme theory. The problem of racial differences has not been solved; it has not yet even been scientifically approached.

The mixed constitutions of the nations of the world have long been recognized by ethnologists, but in the past, theorists have contrasted the French with the Italians and with the Germans and other national groups, blissfully ignoring the variety of discernibly different stocks entering into the make-up of each of these groups. It is encouraging to note that this sort of blundering does not find a hearing as easily as it did a short generation ago. Our attitudes towards the problems of differences of racial stock are so improved and our delusions so cleared that we may reasonably expect that after this war beginnings will be made on the scientific aspects of the problems.

The delusion that language is an indication of racial relationship was one of the obstacles to the approach to the problems. Another delusion, equally obstructive, was the notion that the form of the head remains constant in a given stock over a long period of time, regardless of environmental conditions. The "holy cephalic index," however, is no longer a sacred symbol to ethnologists. Aside from the *reductio ad absurdum* of the cephalic doctrine subtly given in Dixon's *Racial History of Man* (1923), cumulative evidence concerning changes in the head form in man and in domestic animals moving from one region to another where climate, food, and water are different has shattered the prestige of this symbol and relegated it to the class of growth-characteristics, along with other body proportions which have long been admitted to be unreliable signs of racial stock. The fact that the "goiter regions" of the world (regions in which immigrants from other areas are conspicuously subject to goiter) are also regions in which the peoples long resident are brachycephalic is a significant item in the list of weaknesses of the cephalic theory.

The signs of racial stock which must be employed in scientific studies of the racial problems are those physical characteristics which are least affected by the environment. These signs are eye coloration and hair coloration. A third characteristic which may eventually be of use is that of the skin; but the skin characteristic is complex, and the three factors involved—bleached brightness, rate of darkening (tanning) in the sun, and limits of darkening—are associated in various ways in different individuals and have never been analytically studied. Genetic studies which have confused or ignored these factors have given us no useful information, and the employment of skin characteristics in racial investigations must wait on scientific study of these factors, as well as of the actual color features of skin. Classification of peoples as 'white,' 'brown,' 'yellow,' and 'black' has so far been thoroughly confusing, for some 'whites' become almost black in the sun, while some 'browns' darken very little; and some persons who darken rapidly do not tan as deeply as others who tan more slowly.

Hair colorations blend in mixtures of stocks, giving rise to gradations between red and blond, red and dark brown, and dark brown and blond. Eye colors may blend, but in most cases combine in mosaic patterns which are overlooked in casual observations; the eyes which have greater areas of brown than of blue often being classed as 'blue.' These casual observations gave rise to the popular superstitions, once approved by geneticists, that eye color is inherited in an all-or-none way, with (in the later Mendelian formulation) brown dominant and blue recessive. Few eyes among mixed populations show single colors, but we may infer from the types of mixtures that some "original" stocks were blue-eyed and others brown-eyed, although violet, green, orange, and even red colorations occur in various stocks. It has been commonly assumed that in the skin there is only one pigment, of brownish hue; but the stock significance of the blue "Mongol spot" has not been investigated. As for hair color, we may assume three "original" sorts:

red, blond, and dark brown (often called 'black'), of which the blond is perhaps the most recent in development.

In the European populations various "original" stocks are blended, of which at least five are historically identifiable, although the common names of these stocks are applied in various ways and always need careful definition. These five stocks are: Celtic, Nordic, Mediterranean, Autochthonous, and Mongolian.

The Celts are properly the peoples who were known to the ancient Greeks as *Keltoi* and to the Romans as *Galli* (Gauls). The early Thracians and Achaeans in Europe, and the Phoenecians and other Canaanites in Asia were apparently of the same stock; and groups from Europe settled in Asia Minor (Galatians) in the third century B.C. The Celts were red-haired and blue-eyed, although under the influence of the "holy cephalic index" the name has in modern times been applied to dark-haired peoples residing in the same or adjacent areas. In ancient times these Celts were distributed across central Europe and down into present France (Gaul), but they did not penetrate Britain until about the beginning of the Christian Era.

The Nordics (as we use the term here) were a blond-haired, blue-eyed people known to the Greeks as 'Hyperboreans' and to the Romans as 'Germans'. They were located, when first known, in the Baltic area, although the blond Slavs of eastern Europe were obviously branches of the same stock. The Nordics were people of an extremely savage culture, given to cannibalism and wanton cruelty; but under the influence of the Romans, and later when they were Christianized, they adopted civilized ways.

By 'Mediterraneans' we mean the descendants of the Pelasgi of Herodotus' accounts, who entered the Mediterranean area from the east in prehistoric times and laid the foundation for the civilization which we have inherited. They were modified by mixture with Celtic and autochthonous stocks, but apparently the original type was brunet and brown-eyed. Ethnologists of the nineteenth century confused the Mediterraneans, unfortunately, with the Hamites, who are of a different breed.

The autochthonous peoples of Europe, that is to say, the earliest known inhabitants whose stock still persists, have been given no collective name. The variations in body form and in head form, according to the areas of long residence, are probably responsible for this. The type is brunet of hair, with brown eyes. They were widely distributed in Europe and in the British Isles. Various ancient groups in western and southern Asia were probably the results of eastward movements of this stock.

The autochthones were apparently driven northwards from southeastern Europe by the Mediterraneans and Celts, into the mountains. After the exhaustion of the nations of the Mediterranean area and Asia Minor by the Trojan War, the autochthones seized the opportunity to move down upon the civilized areas of the South. The "Return of the Dorians" was but a sample and symbol of the migration of wild tribes which upset the southern populations, ended the power of Egypt in Asia, extinguished the lingering fragments of civilization in Mesopotamia, and would have extinguished the Ionian civilization of Greece except for its flight for refuge to the shores of Asia Minor. In Greece the Dorians eventually weakened and adopted some features of the culture of the peoples they had enslaved; but the savage invasion was a terrible setback to the growth of civilization.

The term 'Mongol,' 'Mongolian,' or 'Mongoloid' covers a variety of peoples of central and western Asia who have migrated into Europe at various times. The various groups known as Ugrian, Turki, Tatar, Hun, true Mongol, etc., are of uncertain relationship to one another; and the use of the terms above is not intended to be more than the convenient adoption of popular phraseology.

The first mass invasion of Mongolians in historic times was that of the Chazars (Khazars), who moved into the Black Sea region about 500 B.C. and later moved northward and eastward up the great river valleys. They were converted to Judaism en masse about 700 A.D. According to one theory, they have been absorbed into the autochthonous populations, whereas another theory identifies their descendants as the present eastern Jews (the Ashkenasim). There were,

however, groups of savage Asiatics already in the eastern regions of Europe when the Khazars moved in, in addition to Asiatic nomads who had infiltrated the whole Balkan area.

The Bulgars, who gave their name to the Volga (Bulga), were a savage group not distinguished by early modern writers from the Huns, whom they equalled in ferocity, cruelty, and destructiveness. The Magyars, whose stock is still an important factor in the Hungarian population, were originally Asiatic nomads, thought by Keane to have been akin to the Khazars. The early Prussians were a mixture of a Mongolian stock with autochthonous and Slavic stocks. An Asiatic stock called 'Ugrian' (the term is properly the name of a language, not a race) entered Europe in prehistoric times, and their hybridization with Nordics and autochthones produced the Finns, in whom today all three types, or approximations to them, appear.

The second mass invasion of Asiatics in historical times was that of Attila in 445 A.D. The horde of Attila included Mongolians of many types, who are commonly designated as 'Huns.' The Huns penetrated central and southwestern Europe, but their power was crushed in 451 A.D. The horde, however, never withdrew, but remained to mingle their blood with the native populations of central Europe. The German war lords of 1914 appropriately adopted the name 'Huns' as a symbol of the ruthless slaughter and destruction which was, and still is, the ideal of their Aryan doctrines.

Although Attila's Huns were not the last groups of Mongolians to move westward, the hordes of Timur the Lame (Tamerlane) did not reach Europe. They unsettled, however, the already mongolized populations of the Near East and probably accelerated infiltration westward by these peoples. The Turks, who entered Anatolia in the thirteenth century and later and eventually subjugated southeastern Europe, apparently left little of their blood in the European populations.

As far west as central Germany there is an appreciable amount of Mongolian blood in the population. From Hitler's place of origin and from his portraits, we may well surmise that he is of partly mongoloid extraction, although Mussolini may be of straight descent from the old autochthones of the forests. The mongoloid autochthonous element is now in the ascendency in Germany, and the Nordic and Celtic elements are definitely the underdogs. Although, as we have above warned, racial stock may in itself be of no consequence, it is nevertheless true that when a people enthusiastically adopt the ideals of their savage ancestors and attempt to make these ideals actual, their boasted continuity with their savage progenitors is an asset in the building of the immoral morale which contributes to the carrying out of their purposes.

The association of the dominant German group with the Japanese in the present war is curiously appropriate. Although Japan has been under the control of various racial groups since the time of the Ainus, the control at present is in the hands of the Malays, who entered Japan from the south and have gained the ascendency over the older Manchurian element. The place of origin of the Malays is uncertain, but they are classed as 'Southern Mongols.' They have as good claim as the Germans to the name 'Huns,' but we may well assign to both Axis groups the title 'Aryans.' This name has had a foul aroma for fifty years; and since the Germans claim it, and nobody else wants it, we may reasonably assign it to them and their allies, the Japs.

CONVENIENCE AND CONVENTION IN REARING CHILDREN

By LEO KANNER

PARENTHOOD has often been called a task, a job, or a profession. Some writers of popular books on child rearing have set out to prepare parents for this task by telling them what to do in a variety of specific instances, much as a student of chemistry is prepared for laboratory work. If your child refuses to eat, bites his fingernails, or does not obey commands, and you don't know what to do next, you simply look it up in the book and your problem is solved.

There has been no better comment on this attitude than a cartoon which appeared a few years ago on the cover of a widely read magazine. A grim-faced mother, sitting in a chair, has her little boy lying across her lap, bottom up. In her right hand she holds a hairbrush, the immediate purpose of which cannot be mistaken. Her eyes are fixed searchingly on the pages of an opened book which she has in her left hand. What will the book tell her to do?

It would indeed be highly convenient if child rearing were nothing more nor less than a learned job. A famous psychologist wrote not quite twenty years ago in a book which for a time was the bible of literate American mothers: "Many thousands of mothers do not even know that parenthood should be numbered among the professions." Deploring the sad prospect that this profession, "the oldest of the race," was facing failure, he proceeded to instruct mothers when and how they should, or preferably, should not kiss a child, how spankings should be administered and dosed, how a child's bath should be made "a serious but not gloomy occasion." My dear professional mother, aren't we making life comfortable for you? Memorize the rules, and all will be well. Knowing all the rules, you will be able to manage your child as, with the help of a good cookbook, you manage your cuisine. And, by the way, is there any reason why you shouldn't turn your nursery over to a well-instructed governess, as you delegate your kitchen to an efficient cook? You could then enjoy your game of bridge and your other social affairs, with the reassuring knowledge that all the rules are carried out to the dot.

But something must be wrong somewhere. Conscientious, painstakingly punctilious mothers flock daily to physicians' offices and clinics. They have tried to live up to all the instructions read in books and heard from lecturers, yet things don't seem to work out right. Calories and vitamins have been checked carefully, appetizing food has been served in dishes which satisfy all esthetic requirements, and Johnny still fusses over every morsel. Dorothy has been taught the rules of politeness and made to understand the tremendous social importance of saying "Yes, sir," and "Yes, ma'am," but when a visitor arrives, she just stands there, thumb in mouth, and does not utter a sound. Alice has been guarded zealously against any possible source of infection, yet she has more colds than any child in the neighborhood. Bobby has been kept away from every opportunity to hear about ghosts and kidnappers; nevertheless, he wakes almost every night, frightened, and insists on being taken into his mother's bed.

The mothers of Johnny, Dorothy, Alice, and Bobby are puzzled. It is so convenient to know that you have a definite job with definite rules and that you have carried everything out to the letter. Why didn't it work? They want to know wherein they or the instructions have failed.

What is the answer?

The simplest answer is often one that seems remotest. Witness the story of the egg of Columbus. Witness the abstruse "primitive" forms of cosmic orientation in which a multitude of contemporaries is still deeply and militantly immersed.

It took thousands of years for the simple truth to emerge and be accepted by science that genuine parental affection is as much an essential prerequisite of wholesome development as is the need for food and shelter.

Genuine parental affection cannot be learned from books or lectures. It cannot be intellectualized and catalogued into any set of rules of the thou-shalt and thou-shalt-not variety. It is not, as a threadbare slogan has it, the outgrowth of a mythical "maternal instinct." Motherhood is, strange as it seems, not always synonymous with genuine love of children.

Genuine parental affection stems from a combination of fortunate experiences and emotional attitudes. Security, adequately sublimated emancipation from childhood ties, matrimonial happiness, and reasonable freedom from obsessiveness are among the basic ingredients. This combination occurs often enough to produce a majority of fond fathers and mothers whose parenthood is "the real thing" and not a job or profession to be studied in detail. If the real thing is absent, clinical experience shows that even the strictest mechanical adherence to prescribed rules fails to make a child develop wholesomely and happily. If the real thing is there, the parents, whether or not they have read books and listened to talks on child rearing, will satisfy their child's fundamental need for their affection.

Goethe has compressed into one profoundly wise sentence the answer to the quest of many philosophers who, in heavy tomes, tried to account for what makes groping man steer past the numerous obstacles and temptations which life puts in his path: "A good man, though beset by puzzling urges, is always sure to find the proper way." A genuinely fond parent, one who can accept the child warmly and unreservedly, will, like Goethe's "good man," find the proper way, not allowing perplexities to gain the upper hand.

For there will always be perplexities.

It would, of course, be most convenient if a child grew up without ever presenting any kind of "problem," if he always ate as much as his mother wanted him to eat, developed toilet habits at a given age, conformed to tabulated standards of height and weight, and immediately complied with every demand. But, fortunately for the human race, no healthy, sturdy child is perfect in the sense of a wound-up robot who never fails to carry out the functions intended by his originator. A fond parent does not expect this sort of perfection. Minor deviations from precision are regarded good-naturedly and treated with unperturbed resourcefulness; they certainly do not become the source of major parental inconvenience. Such parents are amply rewarded in at least two ways: their affection prevents them from becoming grossly annoyed and angered by the little departures, and their child, thus reared, has no opportunity nor need for really disturbing rebellion or withdrawal.

But to a mother who does not fully and wholeheartedly accept her child, these departures, which are a part of the process of growing up, present a personal affront, a sin which the child commits against her as a parent. Her orientation is that of a punitive, retaliating authoritarian. When she brings her child to the clinic, her complaint takes the shape of hostile accusation. She expects the physician to do something—she does not know what—to the child to make him more acceptable to her or to tell her in so many words how she should remodel the child whom she cannot accept as he is.

Of course, the realization of hostile feelings toward one's offspring, condemned by society as unnatural and reprehensible, would be even more inconvenient and unacceptable than the child himself. The rejecting parent needs a face-saving "reason" for the rejection outside his or her own emotional condition. There must be something within the child which makes him objectionable.

Ethnologists tell us of whole communities which could not tolerate differences from the ordinary course of development. There were savage tribes that exposed or killed infants whose upper incisors erupted before the lower ones. This change of sequence, which to us appears innocuous enough, was viewed as evidence that the baby harbored within him the wrath of demons who must be appeased by the victim's death.

Our own conventions, our own traditional ways of thinking have discarded the demons quite some time ago. Even the spells and curses, superstitiously believed to produce illness and misconduct, have been relegated to small, unenlightened areas hidden from the paths of modern civilization. The ire of supernatural beings can no longer serve as justification for rejecting a child; it had to

be replaced by something more in harmony with current conventions.

Ours is a scientific age. The advances of science are transmitted to the public in the form of manifold new technical devices and, by way of schools, printing press, and radio, through simplified explanations of the basic concepts underlying the inventions and discoveries. On the whole, the popularizers of science are doing a grand job. It is not their fault that many people, even among the psychometrically intelligent, cannot rid themselves of the age-old need for mysticism and magic. This need has brought about a new type of superstition, which is perhaps best characterized as pseudoscience.

Pseudoscience offers to rejecting parents the emotional comfort which they must have if they are not to suffer severely from the full awareness of their attitude. Beneath, they feel guilty enough but, for the sake of self-esteem, cannot allow the feelings of guilt to come bluntly to the surface: Pseudoscience provides welcome relief, mostly in the guise of pseudogenetics and pseudomedicine.

If a child misbehaves, it would be most inconvenient to recognize in his misbehavior a reaction to lack of parental affection and acceptance. The cause must be within the child. Scientists speak of constitution and heredity. These concepts are often taken over by the laity as ready-made interpretations of any physical anomaly or deviation from postulated norms of conduct. We are, after all, barely one generation removed from the time when a highly arched palate, an adherent earlobe, and a Darwinian tubercle were considered as "stigmata of degeneration," evidencing inherent "predisposition" to villainy and prostitution. Even today there is still considerable controversy in scientific circles about certain grossly and repetitiously nonconforming people whose inaccessibility to reforming efforts is referred to a preordained congenital quality, spoken of as constitutional psychopathic inferiority.

What greater comfort is there than the assumption, derived from pseudogenetic wisdom, that a child's "nervousness," or "stubbornness," far from reflecting parental attitudes, can be traced to some kind of predestined "remote control"? The hunt for a skeleton in the family closet is hardly ever unproductive; at least some collateral antecedent can be found, usually a black sheep, who in his early years had demeaned himself "just the way Johnny does." Johnny, patterned by heredity, can therefore not be accepted as he is; he must be made over lest he grow up to be as bad as the ancestor after whom vicious Nature has contrived to mold him.

If heredity does not oblige, the child's body gets the blame. There are countless pseudomedical notions to chose from. A sick organ exculpates not only the parent but also the child. It is convenient to be able to feel: I am a good parent, and I have a good child; it is a physical illness which causes him to misbehave.

A college graduate mother, insecure, unable to emancipate herself from dependence on her own parents, resenting her husband's failure to walk through life as a replica of her father, encountered great difficulty with her baby son. During her pregnancy, she had made an unsuccessful attempt at aborting him, soothing her conscience with the conviction that she would not be capable economically of giving her child "all the advantages"; her lawyer husband had a nice income, and they had a spacious home and adequate domestic help. When Dickie arrived, she atoned for her efforts to prevent his coming by thrusting all her energies upon him. Child rearing, to her, was a succession of rituals which must be followed to perfection. She was anxious that her child be well-nourished; her parents "liked them plump." She overfed him and when he refused excess food, she started on a regime of forced feeding. Dickie responded with refusal of almost all food. She recalled that her grandmother had died of gastric cancer, had heard that cancer is hereditary, and concluded that Dickie's "lack of appetite" resulted from a "shrunken stomach." Certain that this was a first symptom of the dreaded disease, she took Dickie to many doctors but could not be calmed by their reassurances. The doctors, she suspected, were just trying to keep the bad news from her. Dickie, sent to a convalescent home, offered no problem there and ate splendidly. On his return home, the misery started all over again. His mother decided to seek psychiatric assistance. She

had an opportunity to vent her own emotional involvements. As she did so, she came to see gradually how her entanglements had influenced her relationship with Dickie. She was able to reshuffle her attitudes, and the relationship improved step by step. She no longer needed her grandmother's cancer and the child's "shrunken stomach" to bolster her up. Dickie, now fully accepted by a much more secure mother, no longer needed the resort to the shenanigans which had plagued her. He developed wholesomely and is now a well-functioning high school student.

The difficulty usually comes out into the open when the biologically helpless, and therefore, submissive, "baby" becomes a willing person and his will begins to assert itself by refusing to remain a passive tool of parental domination. It is perhaps for this reason that, in so many complaint statements, the word willfullness is used as a synonym for stubbornness and obstinacy. There are parents who find the emergence of the will inconvenient and upsetting. They cannot accept it for what it is—a natural and desirable acquisition in the evolution of personality. "Will," which finds expression in the presence of alternatives, is deprived from the start of the guided opportunity to choose between alternatives. Nothing except compliance with the parent's will is tolerated. Any show of initiative and spontaneity which does not strictly conform to parental demands is bewailed as "disobedience" and raises the issue of "discipline." And discipline, to such people, means a lesson in unquestioning, uncritical, unconditional surrender.

Disciplinarianism as a basis for child rearing is made respectable by traditional convention. The rod has, since biblical days, functioned as a symbol of prophylaxis against spoiling. Children who are seen and not heard are still extolled by some as the ideal products of child rearing. Bending of the twig is still often recommended in a way which takes little precaution against overbending or even breaking. Habit training is often interpreted as agitated habit enforcement.

The conventional concept of discipline comes as a godsend to rejecting parents. It sanctions and, in fact, prescribes parental autocracy. If the child does not capitulate—and no healthy child does—his remonstrance, in spite of all the seeming inconveniences which it entails, serves as a welcome justification for an attitude of nonacceptance: "How can I be satisfied with a child who does not obey, refuses his cereal, does not empty his bowel at the exact time when I want it emptied, and throws a temper tantrum when I insist? Such a child is 'bad,' and I am entitled to a 'good' child. His badness must be inherited or the result of some physical illness." This is how the resort to pseudogenetics and pseudomedicine fits into the picture.

Psychologists have recognized children's early remonstrance as a normal phenomenon of growth. Some have spoken of a "period of resistance" in the second and third years of life as a natural stage of psychological development. There was a tendency to ascribe this resistance to attributes contained in the anlage; a predisposition to transitory negativism was supposed to be dormant in the newborn, as the milk teeth are hidden in the jaws, to appear in the course of infancy, and to give way to conformity, as the milk teeth give way to permanent teeth. Clinical studies, however, show clearly that the pointing to chromosomal origins disregards something much more real and more readily demonstrable. It shows that so-called resistance is nothing more nor less than a first exercise in choosing between available alternatives, a first attempt at self-assertion. Since the choice cannot, and does not, always coincide with parental expectations, the instances of divergence tend to impress impatient parents as evidences of resistance.

The degree of resistance depends largely on the extent to which force is used in trying to obtain compliance. Force creates an atmosphere of hostility. A child, finding himself surrounded by disapproving autocrats, has the choice between allowing himself to be crushed and fighting back. Most children have enough stamina to fight back. They discover that their refusals are powerful, and the only, weapons at their disposal. "Discipline" acts as a boomerang. The parents, frustrated and offended, meet resistance with counterresistance, and a vicious circle is established. The child and the

parents are contestants in constant warfare. They get "on each other's nerves." The less genuine affection there is for the child, the lower is the threshold of parental annoyance.

Not long ago at a social gathering, the mother of two boys who are now serving overseas in the Armed Forces reported how delighted she used to be when in years past her sons came down on Sunday mornings, sprawled out on the living room carpet and read the funny papers. A short time afterwards, another mother brought her 7-year-old boy to our clinic. She insisted that Tommy was very bad. One of the examples of his badness was his habit of coming down on Sunday morning, sprawling out on the living room carpet, and reading the funny papers. It was the same behavior in both instances. To the fond parent, it gave pleasure and a pleasant memory. The rejecting mother, whose threshold of annoyance was very low indeed, was irked by it and saw in it one more "reason" for her accusing attitude. The two soldier sons had a secure, happy childhood. They had no need for behavioral backfiring. Tommy was a crushed child, in danger of giving up and withdrawing, but still, luckily, possessed enough vitality to continue his struggle, which would have been hopeless without intensive psychiatric assistance.

The nuisance value of a child's behavior, determined by parental emotional attitudes, derives in no small degree from cultural, "conventional" factors. Hardly a better example can be found than that of thumb sucking. For centuries babies were allowed to indulge to their hearts' desire. Medieval artists depicted angels with thumbs in their mouths to give them the appearance of heavenly bliss. Toward the end of the past century, thumb sucking suddenly became a "behavior problem," an "undesirable habit." Parents were told that the thumb introduces pathogenic germs into the oral cavity, that the habit will result in dental malocclusion, and that—so it was decreed in the early days of psychoanalysis—it indicated a "constitutional re-enforcement of the erogenous significance of the lip zone." The author of a widely circulated book on child care warned that mothers who let their children suck their thumbs "are condemned in progressive communities." Commercial killjoys flooded the market with bitter stuffs to be smeared on the offending fingers, thumb guards, modified strait jackets and Elizabethan collars, and other torture instruments. Anxious mothers, who do not wish to be condemned, get up several times in the night to jerk thumbs out of children's mouths.

It is truly amazing how many inconveniences some parents can take upon themselves for the sake of the convenient feeling that their mode of child rearing is directed toward the prevention of future calamity. Behind it all is a disconcerting lack of faith in a child's ability to develop his potentialities without being constantly jerked and forced by agitated adults.

We live in a thoroughly pessimistic age. The grand idea of prevention, one of the greatest medical advances, is linked much too often with gloomy anticipation of disaster. Devils are painted on the wall, and inkwells are thrown at them. Parents who lack genuine affection for their children and genuine faith in them consider themselves under obligation to "prevent" a child from being malnourished by cramming food down his throat, from being infected by keeping him isolated from other children, from having low marks in school by standing over him when he does his homework. Every slightest behavior item which does not measure up to the conventional ideal is viewed with alarm as a one-way ticket to doom and must therefore be forcibly eradicated. A parent, so oriented, is forever occupied with the child. Thus, paradoxical as it may seem, a rejecting parent often becomes an oversolicitous, overprotective, "spoiling" parent. It is such comfort to be able to say: "Of course, I love my child. Behold! I am sacrificing every minute to his welfare. I deny myself many pleasures because I must devote myself to him. I read books and articles on child rearing and follow all the rules. Alas! I am ill rewarded. He does not appreciate my efforts. He is a difficult and ungrateful child."

Such mother love is not "the real thing." It is smother love. The child's rebellion is the only avenue left open to him if he is not to be smothered. It is a normal reaction to

an abnormal situation. The parent sees in it only an invitation to redouble the smothering, to regard the child and his conduct as abnormal, and to want him to be remodeled. The common accusation is: "He is making a nervous wreck of me," or: "He always keeps me on the run."

These attitudes of open or disguised hostility are not the outcome of premeditation. Many parents would be profoundly unhappy if they "knew" that they had such feelings. Freddie's mother, referred to the clinic by the family physician, did not have the slightest realization of her deep hatred of her affection-starved son when she hurled against the psychiatrist what seemed to her the most devastatingly incriminating charge: "Why, you *like* Freddie!"

These attitudes are not the results of intended viciousness. They are indications of emotional difficulties within the parent. Emotional difficulties cannot be remedied by logic, argument, or prescription of rules. They certainly are not helped by social conventions which take sides for or against a child or a parent.

Next to home relationships, school life is the most incisive experience in a child's development. There are many teachers who are fully aware of this and introduce richness and warmth into the classroom. A child who is nagged at home finds himself accepted at school. His secure relationship with the teacher helps him to modify the impression, gained at home, that living means constant looking out for, and getting back at, adult critics and punishers.

But there are also teachers whose own emotional difficulties make them intolerant and autocratic. Their ideal of convenience is a classroom full of little Lord Fauntleroys. Their low threshold of annoyance makes a culprit of every pupil who does not conform to this ideal. Children who are loved and happy at home will usually manage to remain unscathed by schoolmarmitis. But a child who has been made suspicious or rebellious by domestic censure is apt to respond to the teacher's perfectionism as he has learned to respond to parental obsessiveness. His responses, because of their nuisance value, are criticized severely. Home and school close in on him. Parent and teacher sit in judgment over him and find him wanting. His world does not accept him and builds into him a foundation of unhappiness and hostility.

The twentieth century has been called the century of the child. Infant mortality has been reduced. Child health has been improved. The specialty of pediatrics has made tremendous progress. Schooling is accessible to every child in the country. Child guidance clinics are available in many communities. Child labor laws afford protection against economic exploitation.

The century is now in its fifth decade. The world is engulfed in a life-and-death struggle for the rights of man. Man starts out in life as a child. The rights of children include the satisfaction of the fundamental human needs for affection, acceptance, and security. Parent education will have to emphasize these needs. Instead of laying down rigid rules of child rearing, the people who do the educating must help parents, singly and in groups, to be aware of children's rights to growth, spontaneity, and self-expression and to foster them as fond guides and not as carping censors. False notions of convenience must be dispelled. Conventional attitudes must be brought into being which give social approval to genuine parental affection and recognize children's "behavior problems" as safety valves and calls for help rather than nuisances to be suppressed dictatorially.

Then, indeed, will the twentieth century live on in the history of mankind as the century of the child.

SECONDARY EDUCATION IN BRITAIN

By T. D. A. COCKERELL

It may be said of the British that they have two main objectives: the first, to win the war; the second, to make a Better Britain, which in its turn will be instrumental in creating a Better World. Some say, first win the war and then talk about those other aims. But this is surely a mistake, even from the point of view of winning the war. The battle is being waged for the future, and what we do today will affect the country for many centuries to come. It is the sense of this responsibility to the future which inspires the fighters of today; without such hope and faith they might well be discouraged.

Thus the war has helped to clarify the public mind and to develop a patriotism based rather on the future than on the past. People know, or think they know, where they are going, what they are aiming at. Perfection, whether in the individual or in society, is impossible, but we may strive toward it and attain a large measure of success. As we move forward, new vistas will appear; we shall always be on the road, never at the journey's end.

In this striving it is evident that problems of education must take a foremost place. This is recognized in Britain, and even in the midst of war a bill is being passed by Parliament designed to greatly enlarge and improve educational opportunities for all the people. However, very much has been done in recent years—more than most people realize. I was born in England in 1866 and came to the United States first when about twenty years old. I am thus in a position to compare the past of more than half a century ago with the present, and in several respects the progress has been noteworthy:

(1) The old classical curriculum, with its emphasis on Latin and Greek, has given way to a much broader one in which natural science, including biology, has a prominent place.

(2) The secondary schools for girls are now very numerous. Some schools are coeducational, as is customary in America, but many are for one sex, and those for girls are very active and enthusiastic, judging from reports received.

(3) The old grammar school has expanded to include pupils up to seventeen and eighteen years of age, taking them right up to university entrance.

(4) The traditional divisions of society are breaking down, largely under the influence of the schools, and we may expect to see the children of nearly all the citizens in school together, as has long been the case in the United States.

(5) More attention is paid to the status and qualifications of teachers. I observe that the headmasters and headmistresses of all the schools from which I have letters have university degrees. Dr. C. Foster tells me that the teaching staffs are nearly all graduates.

Recently, my wife developed a plan for reprinting my zoology textbook, published by the World Book Company and used in connection with my lectures at the University of Colorado, and sending a thousand copies to the British Board of Education. It was her idea, and I confess that I regarded it with some measure of doubt. I wondered whether a book coming from America would be welcomed and whether it would be used in the schools. However, we heard from Mr. Butler's Department that it would be acceptable, and now that the books have been distributed to secondary schools all over England and Wales, it appears that the gift was made just at the right time and that there was absolutely no prejudice against it on account of its American origin. I refer to this in order to explain how it happened that we received over 280 letters from the various schools, frequently giving very interesting details about their work, their history, or their experiences in the war. From these letters and from some printed sources, especially H. C. Dent's *Education in Transition* (London, 1944), we get an interesting picture of British secondary education at the present time. The impression gained is one of great activity and enthusiasm, but perhaps it is more favorable than the entire

situation justifies, the letters coming from the ablest and most active teachers. In any case, there is great interest in education throughout the country, and it is apparently realized that the Better Britain will be due more to education than legislation, or rather, legislation cannot be very effective unless supported by education.

In order to understand the present position of the schools, it must be remembered that many of them date from very early days and cherish traditions inherited from the past. Mr. S. W. Whitehouse, headmaster of the Alsop High School for Boys at Liverpool, writes: "I began my teaching career at Worcester Cathedral King's School, which was founded in 680 A.D., and about the year 1000 had a saint as its headmaster!" Another school was founded about fifty years before Shakespeare was born; another during his lifetime. The "ffree Grammar Schole of Newport" was founded in 1588 through a bequest from Mrs. Joyce Frankland. The circumstances connected with the founding of this school are dramatic. Mrs. Frankland had only one child, a son, who had finished his course at Cambridge and entered as a law student at Grays Inn. On August 22, 1581, he was riding an unbroken and spirited horse and was thrown and killed. Alexander Nowell, Dean of St. Paul's, being a close friend of Mrs. Frankland, hastened to her and later told this story of his visit:

> The mother fell into sorrowes uncomfortable, whereof I, being of her acquaintance, having intelligence, did with all speede ride to her house near Hoddendon to comfort her the best I could, and I found her cryenge or rather howlinge continually, O my sonne, my sonne! And when I could by no comfortable words stay her from that cry and tearing of her hair, God, I think, put me in minde at the last to say, 'Comfort yourself, good Mrs. Frankland, and I will tell you how you shall have twenty good sonnes to comfort you in these your sorrowes which you take for this one sonne.'

Mrs. Frankland never referred to this advice during the nearly six years she lived after it was given, but in her will left money, as Dean Nowell had recommended, to found scholarships and fellowships at Oxford and Cambridge and to establish a free school for about fifty scholars at Newport in the county of Essex. "For the love I bear to learning and to have youth well brought up and instructed with fear of God, learning and good manners, whereby they may be good members of the Commonwealth."

In 1851 rules were adopted for the guidance of the school. The subjects to be taught were "Writing, Reading, Arithmetic, and Elementary Mathematics, together with Good Manners and all other instruction and learning fit to be taught in a Grammar School." The pupils were between the ages of 8 and 14.

The Hulme Grammar School at Oldham, Lancashire, was endowed in 1606, in the reign of James I, and began to function in 1611 with about thirty pupils. The curriculum was English, Latin, Greek and Good Manners. It seems to have been the case with all or most of these ancient schools that however limited the curriculum, it included and emphasized "good manners."

The Hulme School is now a very active and forward-looking institution and is greatly interested in good will between Britain and the United States. I have a pamphlet giving an account of the Founder's Day Service, February 27, 1942. It is an admirable example of the spirit of the best modern schools, derived from the feelings and thoughts of the teachers and scholars, not from anything imposed from without. The service begins with the Processional with four verses, of which I quote two:

> The changeful years unresting
> Their silent course have sped,
> New comrades ever bringing
> In comrades steps to tread;
> And some are long forgotten,
> Long spent their hopes and fears;
> Safe rest they in thy keeping,
> Who changest not with years.
>
> They reap not where they labored,
> We reap what they have sown;
> Our harvest may be garnered
> By ages yet unknown—
> The days of old have dowered us
> With gifts beyond all praise;
> Our Father, make us faithful
> To serve the coming days.

I cannot imagine that anyone could hear these words without strong emotion. After the sermon, by a Chaplain to the Merchant Navy, they sang as the Recessional "The Battle Hymn of the Republic." This was followed by "The Star-Spangled Banner"

and the British National Anthem, ending with:

Kinsfolk in love and birth,
From utmost ends of earth,
God save us all!
Bid strife and hatred cease,
Bid hope and joy increase,
Spread universal peace,
God save us all!

Enclosed with this came a sheet "The True Hulmeian," a Credo written by an Old Hulmeian serving with the Royal Navy, at sea, October, 1942:

I believe in the dignity of hard work, whether with the head or hand, that the world owes no man a living, but that it owes every man an opportunity to make a living.

And in the supreme worth of the individual.

I believe that every right implies a responsibility; every opportunity an obligation; every possession, a duty.

And that the rendering of useful service is the common duty of mankind.

I believe that truth and justice are fundamental to an enduring social order.

And that the law was made for man and not man for the law; that government is the servant of the people and not their master.

I believe in the sacredness of a promise; that a man's word should be as good as his bond; and that character—not power, or position or wealth—is the true test of human values.

And that thrift is essential to well-ordered living and that a reasoned economy is a prime requisite of sound structure, whether in personal, business or government affairs.

I believe in an Almighty and an All-Wise God, named by whatever name, and that the individual's noblest fulfilment is to be found in high ethical integrity and self-discipline.

And that Right can and will inevitably triumph over Might.

In such ways have the ancient schools developed, and it is not surprising that they are jealous of any domination from above or interference with their customs or ideals. A Canadian teacher once gave me an example of blind bureaucracy, which, he said, greatly irritated the teachers in the schools. The Inspector came around and found the teachers marking the absences from class. "This will not do," he said. "You must instead mark those who are present." This is an extreme case, but it shows what is possible. But so far as I can learn, the Board of Education in Britain has a very elastic policy, permitting wide diversity, but requiring the schools, if they are to get a grant in aid, to do well what they profess to do. This applies equally to the Catholic schools, from which I have received very cordial letters.

In America we have heard complaints of the domination of the secondary schools by the universities, but we must agree that the prospect of continuing education affords a valuable stimulus. In my early days we had the University Matriculation Examinations, given all over the British Empire. The same papers were sent to London and were read by examiners who made this their regular occupation. In this way any high school, no matter where it might be, could be compared with others, and a certain uniformity of teaching resulted. This standardization was no doubt beneficial in many ways, but we used sometimes to wonder whether it did not go too far, inhibiting originality and special adaptation to local conditions.

The only criticism I received about my zoology text was, in a very few letters, a question whether the topics, or the manner of their treatment, might not quite suit the examiners. There is, of course, a strong tendency for a body of professional examiners to develop fixed ideas, not in keeping with the progress of science. We like to think that we are teaching Truth, but if Truth is Reality made manifest, we must recognize that new truths are constantly emerging, modifying our previous opinions. This contrasts strongly with the dogmas of religion, and to some people seems to suggest the futility of science. But we must progress and, while teaching and acting according to our best understanding, look forward to constantly increasing wisdom in the future.

The education of women in Britain has gone forward to an astonishing degree in recent years. I recall very clearly when women who sought university education were ridiculed and called "blue-stockings." Gilbert and Sullivan wrote a play to hold them up to scorn. When Cambridge established a girls' college (Girton), it was placed far from the town to avoid contaminating influences. But later a second college (Newnham) was placed in the midst of Cambridge. Visiting Newnham College, I saw in the great hall a large painting of a man in academic costume.

"Who is that?" I asked.

"He was undergardener here."

"But how could that be?"

"Well, he was Professor Sedgwick, a famous professor in the University, but his wife was Mistress of Newnham. He naturally desired to live with his wife, but there was a statute to the effect that no man might sleep in the College except a few servants whose duties were specified. So the professor received the appointment of undergardener."

Thus were the girls guarded. One is reminded a little of the comment made by a Mohammedan we met in the Orient. Said he: "We value our women and keep them shut up where they are safe and screened from the vulgar gaze. You treat your women as if they were of no account and let them rattle about the world." And, indeed, in recent years women have been exploring the most remote countries without male escort and coming to no harm.

Miss Winifred Appleton of the Northgate School for Girls at Ipswich sends me interesting details about the education of girls. There was mention of a girls' school as early as 1709, but in 1737 the Directors of the school passed the following resolution:

> Whereas the girls have for some years past been taught to write at considerable expense, without the order of the Governors, it is now ordered that no girls henceforth be taught to write at the expense of the Society.

Ninety years passed before girls were put on something like an equality with boys. A minute of July, 1826, provides for "writing and ciphering for girls during the last two years, and a female assistant to be appointed to teach same."

Erasmus Darwin, the grandfather of Charles Darwin, quoted by Charles Foster (*School Science Review*, December, 1939), made the following suggestions concerning the education of girls in 1797:

> Besides the acquisition of grammar, languages, and common arithmetic, and besides a knowledge of geography, and history, and natural history, there are other sciences, an outline of which might be taught to young ladies of the classes of the school or of more inquiring minds, before or after they leave school, which might not only afford them present amusement, but might enable them at any future time to prosecute any of them further, if inclination and opportunity should coincide; and, by enlarging their sphere of taste and knowledge, would occasion them to be interested in the conversation of a greater number and of more ingenious men, and to interest them by their own conversation in return.

But I recall that, in my young days, it was considered bad manners to discuss any technical or scientific subject with a woman, as she, being ignorant, would be placed in a humiliating position.

Today, the very numerous and very modern schools for girls take them up to university entrance, and many enter the universities or colleges. Thus, for instance, the large girls' school at Luton, Bedfordshire, reports that many of the girls are looking forward to careers in medicine, teaching, agriculture, and nursing. The County School for Girls at Penzance, Cornwall, reports that they have nearly three hundred pupils and that they "prepare them for the School and Higher Certificates of the University of Oxford. Many of them go into banks and offices when they leave school, but a good proportion go on to universities and ultimately go in for secondary teaching, the Higher Civil Service, or medicine. Many become teachers in elementary schools after two years' training at a training college, and a number go in for nursing." At the High School at Newark-on-Trent the girls not only prepare for the university, but also for a variety of professions of social importance in the community. So it goes in many schools, and it is evident that a new era for women is opening up. The reforms in teaching and medicine now being initiated will call for great numbers of teachers and doctors, and many of these will be women. Whatever may be the present attitude of the government, there can be little doubt that before very long the pay and opportunities for women will be similar to those for men.

When I was a boy in a private school at Beckenham in Kent, the nearest approach to science we had was half an hour of geography once a week. The teaching of science in the schools came slowly, and the tradition was that real erudition was largely confined to a knowledge of the classics. We recall a satire of those days directed to the attitude of the learned:

> I am Benjamin Jowett—
> Master of Baliol College;
> Whatever is known, I know it,
> And what I don't know isn't knowledge.

It must be said for such men that they were not only classical scholars, but culti-

vated gentlemen, worthy members of their communities. The ancient culture was well defined, whereas the science of the day was largely amorphous, not too certain of itself. Indeed, this difficulty will not be overcome; the adherent of a static system of knowledge or philosophy has a certain advantage over one whose subject is in a continual state of flux, always progressing and being more or less made over. It is only when we have accepted the view that progress is the normal condition of mankind, just as it is the normal ambition of the individual, that we can escape from the old systems of fixed ideas. And so escaping, we encounter hazards, and know very well that we are sure to make mistakes.

Dr. Charles Foster (*Annals of Science*, July, 1937) quotes Dr. George Birkbeck on the origin of the Mechanics' Institutes at the end of the eighteenth century:

> I resolved to offer a gratuitous course of elementary philosophical lectures. When the plan was matured it was mentioned to some of the wise in their generation. They treated it as the dream of youthful enthusiasm, and scarcely condescended to bestow upon it a sneer, for it appeared to them so thoroughly visionary and absurd. They predicted that if invited the mechanics would not come; and if they would come they would not listen; and if they did listen they would not understand. The offer, however, was made. They came, they listened, they conquered; conquered that prejudice which would have consigned them to the domination of interminable ignorance, and would have shut the gates of knowledge against a large and intelligent portion of mankind forever.

In the early nineteenth century, the teaching of scientific subjects, initiated by the Mechanics Institutes, spread to the schools, but slowly. Foster says the recognized teaching of science in secondary schools dates probably from about 1870. In the meantime, public lectures and "Penny Readings" were popular and served to convey to the people much information not offered in the schools.

Science teaching in the past has emphasized physics and chemistry rather than biology. This tendency has naturally been stimulated in later times by the many important discoveries and inventions resulting from work in these fields. I notice in recent discussions supporting scientific work that almost the whole emphasis is often placed on the production of material wealth. No one, today, would deny the value of this work, even though, through the wickedness of man, it has in part had such lamentable results. But more should be said in favor of biological studies, which, as in medicine and agriculture, have given results which lengthen life and bid fair to abolish poverty, while at the same time have great cultural value. It seems that this is coming to be realized in the British schools. I find that the many letters received nearly all refer to some biological work being done. Dr. C. Foster of Buckingham writes:

> There has been a great development in the teaching of biology during the past ten years. Not many schools are large enough to give specialized teaching in biology to a very high standard as yet although that is what we are mostly trying to do. The great majority of schools have now adopted schemes for the teaching of "General Science," in place of the old physics and/or chemistry, and, in this, biology takes quite an important place. Thus nearly all secondary schools give some kind of biological teaching.

With regard to the cultural value of biology, we have long had many amateur naturalists—entomologists, conchologists, botanists, ornithologists, and so forth. These groups have greatly enjoyed their work and stimulated good fellowship between many who would not otherwise have come together. An important factor has been the production of small, well-illustrated books on different aspects of natural history, and another influence has been that of the local museums. There are magazines devoted to the natural history of particular regions. Some of these amateurs have become professionals or specialists, but on the amateur level there is much for the public good. England is surely one of the most beautiful countries in the world, with truly remarkable fauna and flora. Thus the English patriot thinks of those things, as well as of the people and the buildings and the history of other times. It is an important part of education to emphasize these things and bring them to the attention of the pupils. I like the attitude of Miss Jeanne Harrison of the School for Girls at Penzance, Cornwall:

> The school is a granite building on a hill on the outskirts of Penzance and overlooking St. Michael's Mount and the bay. It has a most beautiful position. When I first came here last May I could hardly

gate yearly photosynthesis of marine plants, mostly diatoms, is at least twice that of terrestial plants, an estimate of which has been given above. Like the brown algae, these plants contain chlorophyll *c* instead of chlorophyll *b*. The xanthophylls present are different from those in higher plants; some, including fucoxanthin, are identical with those found in the brown algae. Diatoms are brownish or yellowish because the quantities of xanthophylls present are sufficient to obscure the presence of the chlorophyll.

The group of red algae (*Rhodophyceae*) includes most of the smaller "seaweeds," especially in the warmer oceans. These plants contain neither the chlorophyll *b* of green algae and the higher plants nor the chlorophyll *c* of the brown algae and diatoms, but chlorophyll *d*, which seems to be restricted to plants of this group. Xanthophylls are either lacking or else are present in exceedingly small quantities. The predominantly red color of plants of this group results from the presence of the pigment phycoerythrin.

Yellow green algae (*Xanthophyceae*), a group resembling the green algae, are distinctive in that they appear to contain only the *a* variety of chlorophyll. The xanthophylls of these plants also appear to be different from those of other kinds of algae.

The examples given are sufficient to illustrate the point, although they do not exhaust the possibilities. Several other groups of algae, each with a more or less distinctive pigment complement, have not even been mentioned. It is highly probable that additional chlorophylls and xanthophylls will be discovered in the photosynthetic tissues of plants.

The existence of different chloroplast pigment systems in the algae of different groups suggests that the photosynthetic mechanism may not be identical in all kinds of algae. The mechanism of photosynthesis, like the pigment system, appears to be the same in all the higher plants and in the green algae. Practically nothing is known of the actual mechanism of photosynthesis in algae of other phyla. However, some algae, notably the diatoms and yellow green algae, unlike other green plants, accumulate considerable quantities of oil in their cells. Petroleum deposits, in fact, are commonly supposed to have resulted from the physiological activities of diatoms of past geological eras. Whether or not the accumulation of oil in the cells of diatoms is a direct consequence of some distinctive feature of their photosynthetic mechanism is not known, but it is a suggestive fact in connection with the known pigmentation differences among algae.

That the mechanism of photosynthesis is not identical in all plants has already been shown on a limited scale. In the purple sulphur bacteria, a little-known group of organisms, occurrence of photosynthesis does not result in any release of oxygen into the environment as it does, so far as is known, in all other photosynthetic organisms. These plants contain only one kind of chlorophyll which is of a different variety from that known for any other kind of plant. They also contain certain yellow pigments.

Extensive investigation of nature's different versions of the photosynthetic process will not only contribute to the broadening of scientific knowledge, but may make more direct contributions to human welfare. It has long been a dream of scientists to be able to capture the sun's energy directly, without the intermediation of the green plant. The best possibility of by-passing the green plant in the acquisition of radiant energy is by means of some purely physical photochemical reaction, more or less analogous to photosynthesis. The more we know about the chemical mechanics of the photosynthetic processes of plants, the structure of the molecules of the pigments involved, and the kinds of products formed, the more likely it is that some day we shall be sufficiently fortified with knowledge to realize this goal.—B. S. MEYER.

BOOK REVIEWS

THE PSYCHOLOGY OF WOMEN

The Psychology of Women. Helene Deutsch. xiv + 399 pp. $4.50. 1944. Grune and Stratton.

THIS is a psychoanalytic interpretation of the psychology of women from their early years to maturity, by a psychoanalyst of considerable experience who has made woman her special study. A second volume will deal with the psychology of adult womanhood.

The book will be of particular interest to teachers, parents and, of course, psychologists, for Dr. Deutsch manages to throw much light on many obscure problems connected with woman, of whom it has been correctly stated that "age cannot wither her, nor custom stale her infinite variety." Many readers will find in the pages of this book much with which they will be unable to agree, and they may find its style somewhat arid, but they will carry away with them some new insights into the psychology of women. Heyman's *Psychologie der Frauen* (not mentioned in the present work) was a much more readable book and very informative, even though it was published over thirty years ago, but it was written from a more formal psychological standpoint.

On the whole this book may be recommended as an original and stimulating contribution to our understanding of woman. We look forward with interest to the publication of the second volume.—M. F. ASHLEY MONTAGU.

THE AMERICAN NEGRO

Characteristics of the American Negro. Edited by Otto Klineberg. 409 pp. 1944. $4.00. Harper and Brothers.

IN this volume there have been brought together a number of the monographs prepared in connection with the *Study of the Negro in America* under the direction of Dr. Gunnar Myrdal and the sponsorship of the Carnegie Corporation of New York. In a sense, therefore, this volume is a sort of omnibus for rather generally-connected studies: "The Stereotype of the American Negro" by Guy B. Johnson; "Tests of Negro Intelligence" and "Experimental Studies of Negro Personality" by Otto Klineberg; "Race Attitudes" by Eugene L. Horowitz; "The Hybrid and the Problem of Miscegenation" by Louis Wirth and Herbert Goldhamer; "Mental Disease among American Negroes: a Statistical Analysis" by Benjamin Malzberg. As one reads the volume, one is struck by an inherent tendency of the subject matter to overlap and a more serious conflict of terminology, especially with reference to the use of *race* and *racial,* and the frequent substitution of these terms by *ethnic, national, caste,* and similar terms. Since the personality of the American Negro is vitally affected by how he is racially defined, it seems imperative that scholars agree on this definition, its biological basis, and its social interpretation.

The presentation of the stereotype of the American Negro is itself a stereotype: quotes from various printed media, scientific and unscientific, which delineate more or less popular concepts of the Negro and Negro-White relationships. Johnson himself observes that evaluation of such a method of assessment is far from satisfactory; it is subjective, personal, and leads to no really sound concept of Negro personality and culture traits. Klineberg offers more objective material in the form of scores and ratings based on various performance tests. Klineberg presents some new material, but for the most part his two contributions are based on his book "Race Differences." The tabulation of calculated scores, arranged in a hierarchical rating, highest to lowest, pays obeisance to performance rather than innate ability or potentiality. In other words, there is far more a mere measure of achievement level rather than an analysis of educational opportunity—or the lack of it!

The section on attitudes by Horowitz contains much original material, though it leans heavily on Lasker, Moreno, Minard, and Crisswell. Then, too, this section seems to integrate more clearly with the theme of the entire volume, for in discussing the inception of race attitudes it regards personality as a biosocial complex that must take cognizance of race not only as a biological classificatory product, but one which is molded by, and

molds, social reactions as well. Horowitz reaffirms the familiosocial basis of race attitudes (really race prejudices) during the early grade school years. In a sense Wirth and Goldhamer extend the biosocial theme in their study of miscegenation as they analyze the social problems engendered by the biological process of Negro-White intermixture. They are not concerned so much with the genetics of such crossing as with emergent cultural patterns and problems, and as a result chapters on provenience, intermarriage, passing, and personal characteristics of hybrids are more adequately treated than the chapter on physical characteristics of hybrids. But this fact does not detract from the all-around value of their contribution: the hybrid emerges as a distinct social entity and a potent cultural force.

Malzberg statistically affirms what Klineberg has earlier implied, viz., that the mental test differences that do exist between peoples are not biological, i.e., not neuromuscularly innate, but socially conditioned.

The volume is a welcome and a real contribution to our knowledge and understanding of the American Negro. Read it and read it carefully: you'll find that intolerance and prejudice are overcome before a steady and logical march of facts and interpretations.—W. M. KROGMAN.

REHABILITATION

Principles and Practice of Rehabilitation. John Eisele Davis. 211 pp. 1943. $3.00. A. S. Barnes and Co.

NOWADAYS, at every turn in medical literature, in lay journals, and in the daily press, one finds the word "rehabilitation" freely used. That this is true is a healthy sign, for it means an interest in the disabled, whether of war or peace, and in their restoration to useful lives, even though this prodigal use of the term inevitably means a broadening of its connotation, with a corresponding decrease of its denotation.

Most people, when they speak the word, think of the physically disabled — the maimed, the deaf, the blind. To limit the use of the term to designate these groups is erroneous; it is equally wrong to apply the word *only* to those suffering from mental disorders. This latter is precisely what Dr. Davis does, and to that extent his title is misleading. The subject matter, however, is entirely sound, as we should expect from so experienced and careful a worker in the field of recreational and occupational therapy as applied to psychiatric problems. Dr. Davis' work at the Veterans Facility at Perry Point, Maryland, has long been outstanding.

The chapter headings are: Effect of War and Depression; Psychiatric Approach (brief discussion of the main clinical entities); Psychological Approach (largely a presentation of some tests, but omitting mention of Doll, Wechsler, Rorschach or Murray); Interest and Effort Theories; Elementary Principles of Mental, Nervous and Physical Reconstruction; Modern Methods; Therapeutic Objectives and Results; Handicraft, Education and Art. There are numerous helpful charts and diagrams, most of them devised by the author. There are also numerous illustrative case histories.

Dr. Davis is an eminently practical man, and his chapters on practice are the best. He is a leader in his field, and his volume is a useful contribution to the literature. Everyone interested in the psychological aspects of rehabilitation should read it.—WINFRED OVERHOLSER.

MANKIND SO FAR

Mankind So Far. William Howells. Illus. xii + 319 pp. 1944. $4.50. Doubleday, Doran and Co., Inc.

THERE is a rapidly mounting curiosity among Americans at the moment regarding the peoples of other parts of the world. Not only has the war made us more aware of distant races of mankind, but it has confused us on the very concept of race. Dr. Howells' book, with its perspective on mankind, thus comes at an opportune time.

This book is directed at the general reader and does not presuppose a college course in zoology; it starts by explaining the vertebrates and carries their evolutionary classification from fish through amphibians, reptiles, and the lower mammals to the Primate Order. The anthropoid apes then receive fairly detailed consideration and finally man himself—in his fossil, recent, and future forms—is dealt with in the last two-thirds of the volume. By picturing man in this broad zoological setting in such a way as to

attract a wide audience, Dr. Howells has had to devote considerable space to lower forms and consequently curtail his description of man—even to the point of omitting contemporary distributions. Many readers who have been attracted to this subject by current events will be disappointed by this omission and more so by the lack of a bibliography to aid them in further search for this information.

Considered within the limitations of its scope, however, Dr. Howells' book is well written. Technical expressions are cleverly avoided or explained without giving the reader the impression of being "talked down to." As a sparkling example, ischial callosities are described as:

> . . . a tongue-twisting euphemism for those two gay and shining patches of bare, tough skin in that region described by Mr. Westbrook Pegler as the sole of the pants. A mandrill, therefore, gives you bright greeting whether he is coming or going; reversing the day, his face, red, purple and blue, recalls the sunset, while his departing presence imitates the dawn.

If there is any criticism of such an interesting style of writing, it is perhaps that scientific concepts are not always made entirely clear. Thus, on the first page it is stated that man's ". . . organization and all his parts go back, lock, stock and barrel, to the anthropoids . . ." Now many readers will know of the contemporary apes as the anthropoids and so will be confused by the use of this term synonymously for fossil and modern forms. In this connection they may be startled when they get further along by the statement that ". . . the gorilla's likenesses to man do not necessarily signify that man descended from him."

Other examples of this style, which perhaps emphasize contradictions because of the lack of context, are the following: "Evolution is a fact, like digestion." "It is like saying that you are descended from Charlemagne; it can't be proved, but there is, nevertheless, little doubt of it, considering his family life." "Man used [brachiation] also, while he was an ape, but on becoming a man he suddenly specialized intensely . . . His uprightness is unique. . . ." "The great mark of the apes is that they are invariably upright in posture."

Actually, such minor faults may be more apparent to specialists than to general readers and probably are of small consequence when compared with the great mass of facts and interpretations accurately and interestingly presented. The summary and analysis of the fossil human record in particular are quite comprehensive. Indeed, the good features of this book predominate and make it both a useful and worthy member of the American Museum of Natural History Scientific Series.—T. D. STEWART.

THE PACIFIC

The Pacific World. Edited by Fairfield Osborn. Illus. 218 pp. 1944. $3.00. W. W. Norton & Co.
Pacific Ocean Handbook. Eliot G. Mears. Illus. 192 pp. 1944. $1.00. James Ladd Delkin, Stanford University.

IF war has any benefits at all, one of them certainly is the stimulus it gives to the increase and dissemination of human knowledge in various fields, and in the present "global war" geographical knowledge has benefited outstandingly. One wonders sometimes, however, what our soldiers, sailors, and marines themselves think of the dozens of handbooks, aids, guides, and manuals that are prepared for their edification, and whether the military prosecution of the war might not sadly suffer if they took time to read them all. Be that as it may, many excellent and useful works have lately appeared, those listed above being two of the most recent additions to the "handbook" literature of the Pacific region.

Mr. Osborn's book, sponsored by the American Committee for International Wild Life Protection, is a compilation designed to give a general picture of the entire Pacific, "its vast distances, its lands and life upon them, and its people." In so small a book, covering so great a territory, there is room for only the barest exposition and description. Beginning with an introduction by the ubiquitous William Beebe, addressed to men of the armed services, the book proceeds through twenty chapters, the first eleven dealing with the general geography, discovery and exploration, climate, astronomy, the native peoples, and the natural history; the last nine with regional descriptions of Australia and New Zealand, Melanesia, the Netherlands Indies, the Philippines, Micro-

nesia, Polynesia, Japan, the Aleutians, and other island groups. The book is simply and clearly written, with an obvious effort to appeal to the so-called popular reader. If the book gives the impression of being too sketchy for other than elementary usefulness, it may be explained that a series of supplemental handbooks is being prepared by the same Committee. The numerous charts and maps are especially helpful, for in their preparation graphic illustration rather than adornment has been paramount. The illustrations were executed by Robert M. Chapin, Jr., Andrey Avinoff, Francis Lee Jaques, Joy Flinsch Buba, and Charles Clark. The misspelling of Mr. Jaques's surname is so frequently perpetrated by publishers that it is no surprise to find it again misspelled here both on the title-page and jacket. As our favorite poet once wrote:

> What good is happiness, or health, or fame,
> If only one in ten can spell your name?

Whereas "The Pacific World" stresses the anthropology and natural history of the region, since the sponsoring Committee believed "that literature regarding the animal life of the Pacific islands would encourage its conservation," the Mears volume is written from a more purely physical-geographical approach, Professor Mears himself being a geographer of considerable reputation and an authority on ocean currents. It is a handbook in both size and content—compact and factual—with no other aim than to provide the reader, be he soldier or civilian, with essential facts in the most convenient form. It tends strictly to business and wastes no words. It is not written for the technical expert and at the same time does not write down to too low a level. The neophyte seeking knowledge will find here a wealth of data on all main and peripheral matters pertaining to the Pacific—the Pacific Basin, Oceania, volcanoes and earthquakes, tides, currents, winds, storms, precipitation, fog, navigation, and geomagnetism, to list a few. A dozen appendices provide quick tabular information on such subjects as area and population, standard time, distances, wind scales, sea food for the shipwrecked, weights and measures and currency, chronology, monsoons, coral islands and reefs. All these help to make this book a sort of World Almanac of the Pacific—*multum in parvo*. The illustrations, though small, serve their purpose reasonably well, and for the second edition illustrations have been added and many of the maps and charts have been redrawn and clarified and in some cases enlarged. We understand that the publisher of this handbook has not been able to get enough paper allotted to him to meet the demand of sales. We could, if pressed, suggest considerable current printed matter that might be done without, if it would mean that meritorious publications such as "Pacific Ocean Handbook" could get enough paper to carry on.—PAUL H. OEHSER.

MAN DOES NOT STAND ALONE

Man Does Not Stand Alone. A. Cressy Morrison. 107 pp. 1944. $1.25. Fleming H. Revell.

THE subject matter of this little book is an attempt to consider objectively some of the scientific evidence bearing on the existence in the universe of a Supreme Intelligence. Evidence is presented and elaborated on the postulate that the existing known phenomena pertaining to nature and to mankind and their relationships would be impossible without the existence also of Supreme Intelligence and without the existence likewise of definite purpose in the universe. According to the author, such definite purpose is the preparation of the soul of man for immortality. Numerous interesting facts have been assembled, organized and presented, and equally interesting conclusions have been derived therefrom. The subjects of some of the chapters are self-explanatory: our unique world, atmosphere and ocean, the gases we breathe, nitrogen, what is life?, how life began, origin of man, animal instincts, the development of mind, genes, the world's greatest laboratory, checks and balances, and time. The scope of this notice, however, does not include detailed synopses of the various ramifications of the author's discussion, nor do space limitations here permit of quotations therefrom of sufficient length adequately to illustrate his charm as a writer or the breadth and profundity of his thought.

Although the book should not be considered as being controversial in character, its

title has been selected as a challenge to the conclusions given in a recently published work, written by Julian Huxley, entitled "Man Stands Alone." The author of "Man Does Not Stand Alone" is a past president of the New York Academy of Sciences and of the American Institute of the City of New York; member of the executive board of the National Research Council; fellow of the American Museum of Natural History, and life member of the Royal Institution of Great Britain.—J. S. WADE.

INDEX FOSSILS

Index Fossils of North America. Hervey W. Shimer and Robert R. Shrock. Illus. 837 pp. 1944. $20.00. Massachusetts Institute of Technology Press.

THIS excellent book, designated as a revision of Grabau and Shimer's "North American Index Fossils" published in 1915, because of its scope and wealth of new material embodying the results of research and publication up to Pearl Harbor, so far surpasses the latter that it might well be considered a new book. The 534 pages of text contain descriptions of approximately 2,500 genera and 7,500 species of invertebrates and a few plants, excellent bibliographies of the larger divisions, an index of genera, and one of species. The 303 full page plates contain over 9,400 illustrations of the described species. In addition to the discussions of all major groups of invertebrate fossils, there is a short section on fossil plants and miscellaneous probable fossils which are often encountered by the invertebrate paleontologist.

This should be a "must" book in the library of every American paleontologist. It can well be used as a reference for lecture and laboratory work in courses in invertebrate paleontology and stratigraphy as well as a general reference for all paleontologists and stratigraphers. It is so important that it really deserves review only after one has had time to study and make use of it for teaching and other purposes.

The primary purpose of the book, which has been well attained, is to describe and illustrate as many as possible of the fossils which can be used to identify, date, and correlate formations. No doubt many persons will feel that certain species which they have found useful should have been included. However, it would be impossible in a book of this size to describe and figure all fossil forms which can serve this purpose, and the selections which have been made, even if they do not include all known index fossils, represent the considered opinions of the persons who have selected them.

The book is largely the work of the authors, but many of the sections have been prepared or revised by workers who are specialists on particular groups of fossil forms. Practically all of the large divisions of the text were examined by one or more specialists and many of the smaller divisions are largely the work of other specialists who have given freely of their knowledge. This careful preparation and revision gives to the work merit and authenticity which it otherwise could not have. Due acknowledgments for all contributions in the form of text, illustrations, or other information are completely made.

Sections prepared by colleagues of the authors are as follows: Foraminifera by Joseph A. Cushman, Lloyd G. Henbest, and W. Storrs Cole; Crinoidea by Raymond C. Moore and Lowell R. Laudon; Conodonts by Edwin B. Branson and Maurice G. Mehl; Brachiopoda by G. Arthur Cooper; Insecta by Frank M. Carpenter; Charophyta by Raymond E. Peck; and Calcareous Algae by J. Harlan Johnson. Larger sections revised by specialists are: Blastoidea by Lewis M. Cline, and Paleozoic Gastropoda by J. Brookes Knight, with the collaboration of Josiah Bridge and R. R. Shrock.

The book begins with an introductory chapter in which the authors explain the purpose of the work, the nature and method of presentation of the contents, the sources from which descriptive and illustrative material were obtained, and the extent of contributions and revisions by others. This is followed by definitions of various terms which are used in the text, such as index fossils, form species, form genus, and different types of index fossils.

The introductory chapter is followed by ten others, each of which deals with a major division of invertebrate life, usually a phylum. Chapter 12 treats of fossil plants and miscellaneous objects of probable or-

ganic origin. The order of treatment of the various phyla is arbitrary and was chosen for practical reasons. Description of genera and species of each group of organisms is preceded by a discussion of general characters of the group. These discussions are of varying length depending upon the different authors. In general, however, they are brief because the user of the book is assumed to have a general knowledge of invertebrate paleontology or to have available suitable textbooks from which such information may be obtained.

Genera and species are described according to a definite plan except where some other method is more appropriate. Genera are usually described in taxonomic order, the divisions having the oldest fossil representation first. In a few cases where satisfactory taxonomic grouping has not been made, such as for the Trilobita, the genera have been arranged alphabetically for major time divisions. Species are considered in stratigraphic order, oldest first. Rules of the Committee on International Zoological Nomenclature have been followed faithfully and every effort has been made to insure the proper generic name, author, date, and genotype. Generic and specific descriptions are necessarily condensed but include the most characteristic and diagnostic features. Geologic range and geographic occurrence are given.

Some innovations in taxonomy have been made. Three of the more noteworthy of these are worth mentioning. The Conularidae which in the past have been assigned to various biologic groups, but most commonly to the Mollusca, are herein classed as Scyphozoa. Classification of the Brachiopoda used in this book differs from the generally accepted practice. Two classes, Inarticulata and Articulata, with the two commonly recognized orders, Atremata and Neotremata of the Inarticulata and the order Paleotremata of the Articulata are recognized. Instead of orders Protremata and Telotremata, the remainder of the brachiopods are classified into Impunctate Articulata, Pseudopunctate Articulata, and Punctate Articulata. Although the last three units are not called orders, they are treated essentially as such. Certain small Crustacea, *Agnostus* and related forms, which formerly were classed with the Trilobita, are placed in a separate subclass, Agnostia.

Illustrations have been obtained from various publications, new photographic prints of published figures, new photographs of specimens previously illustrated in published reports, and original and unpublished photographs and drawings. In spite of these different sources the plates are uniformly good, many of them excellent. The plates of line drawings in the section on crinoids are especially valuable to show plate structure.

Adverse criticisms are few. One discrepancy between description and illustrations caught the writer's attention. The trilobite genus *Pagetia* is described as possessing three thoracic segments, yet illustrations of the two described species show only two. There are surprisingly few orthographic errors for a book this size, and these may be typographic. The printing is good with only occasional incomplete or blurred letters. The abundant usage of bold faced and italicized type is especially helpful in emphasizing important matter.

In summation, this book is a work well done. There is no other comparable book in existence. The authors and their colleagues deserve unstinted praise for producing such a splendid volume under the difficult conditions of the past three years. Especially commendable is the waiving of all royalty rights by Dr. Grabau, senior author of the first edition and A. G. Seiler, publisher of "North American Index Fossils," and the assignment of all royalties by Drs. Shimer and Schrock to the Technology Press to help defray the cost of publication. This is truly an example of the scientific spirit.—A. H. SUTTON.

COMMENTS AND CRITICISMS

ON "SCIENCE AND THE SUPERNATURAL"

My Son, these maxims make a rule,
An' lump them ay thegither;
The Rigid Righteous is a fool,
The Rigid Wise anither:
The cleanest corn that e'er was dight
May hae some pyles o' caff in;
So ne'er a fellow-creature slight
For random fits o' daffin.

—ROBERT BURNS

The following letters are expressions of opinion on A. J. Carlson's lecture, "Science and the Supernatural," which was republished in the August issue of the MONTHLY. The first of these letters was addressed to Dr. Carlson; the others, to us. We have asked an eminent scientist to submit an article on the same subject, expressing a different point of view. At the moment we can only add to the letters here quoted some profound and beautiful thoughts (in italics) of great writers of the past.—EDS.

If you will accept a word of appreciation from a member of our A. A. A. S.—a retired Quaker business man holding only a modest degree in Science but a deep interest in scientific progress—I would like to thank you for the privilege of reading your William Vaughan Moody Lecture, as reprinted in the MONTHLY of August.

My pleasure in following the beautifully stated and elaborated points of your dialectic, and sense of very general unity with it, has suggested to me the possible propriety of my writing you with reference to one point upon which I would have greatly enjoyed a fuller expression of your views than you apparently felt warranted in offering. I refer to your brief mention of alleged objective evidence for personal immortality and, in particular, to your suggestion that communications with the dead by clairvoyance, "psychic mediums," and "ectoplasm," may scarcely be dignified as evidence; and that when examined, the "ectoplasm" appears to "go the way of all errors and frauds." You simply comment, rather briefly, that you "know these attempts," and are "still skeptical."

This may seem but a trifling point in the wide sweep of your argument, but I would have welcomed the privilege of learning what you know of these attempts to produce evidence of personal immortality, and your reasons for being "still skeptical." For I have given the subject of evidential value of survival phenomena some years' intensive study, and have come to conclusions that tend to vary somewhat from your own conclusions, if I correctly understand your conclusions to be that such alleged phenomena do not afford reliable evidence.

I do not suggest, for a moment, that the knowledge which I have obtained in this field can bear comparison with your own. I am only wondering how it is, that the 90-year series of investigations by distinguished scientists such as Hare, Crookes, Flammarion and Lodge which I have reviewed; the great number of individual cases I have studied; the several hundred books that I have read; the living investigators whom I have consulted; the score or more of reputable psychical mediums with whom I have held some hundreds of "sittings"; and the easy and evidently quite natural psychical communication with the "dead" which we have been able to develop and maintain in our own family circle—how it is that all these items of experience can build up, as they unquestionably do, into a single consistent picture of evident reality, without there being, in fact, any reality there.

You had, no doubt, personally covered such a minimum program of inquiry as mine, and gone far beyond it, before you felt warranted in expressing yourself as you did. But, as you see, it is not altogether clear to me how you could have done so, and come out at the end, "still skeptical." The vast accumulation of items, wholly consistent with one another, which constitutes the "weight of evidence" for any theory, whether in the physical or physiological field, is here present as undeniably as it was in the case, for example, of Harvey's theory of the circulation of the blood, or Copernicus' astronomical theory, or Mendeleeff's theory of the periodicity of the elements. Is it inevitable that the same prejudice which they encountered on the part of academic opinion, is likewise to plague a soundly based and fully authenticated theory of personal immortality?

I feel that such a body as our American Association is bound to be at a disadvantage with respect to its position on this subject, until it has made that position clearer than your brief comment, as President, makes it. I wish that I might place a small fund in your hands, and ask you to appoint someone to prepare a summary of objective and subjective evidence for personal immortality, as ninety years of experiment and experience have produced it. I think that I could assist such an appointee to obtain a wide measure of able and helpful collaboration.—S. ROWLAND MORGAN.

There is nothing strictly immortal, but immortality.—SIR THOMAS BROWNE.

I want to compliment you on your vision in reprinting Carlson's "Science and the Supernatural" in the August, 1944, number of THE SCIENTIFIC MONTHLY. There is an urgent need today for a much wider diffusion of Carlson's clear-cut thinking on this supernatural question.

I wish that Carlson's article might be reprinted and placed in the hands of every high school teacher in this country.—SAMUEL S. WYER.

Your article "Science and the Supernatural" by our one-track-physiological-minded President, A. J. Carlson, is an insult to the intelligence of members of the AAAS.

Carlson neglects the first and most fundamental principles of science, exactness in definitions and thoroughness in research.

If the editorial staff is so exacting in their science publications, what may be your excuse for resurrecting an article which lacks all the earmarks of scholarship?—D. W. MILHONE.

Believing as I do that man in the distant future will be a far more perfect creature than he now is, it is an intolerable thought that he and all other sentient beings are doomed to complete annihilation after such long-continued slow progress. To those who fully admit the immortality of the human soul, the destruction of our world does not appear so dreadful.—CHARLES DARWIN.

I wish to express my appreciation of the article entitled "Science and the Supernatural" by Dr. A. J. Carlson, which appears in THE SCIENTIFIC MONTHLY for August, 1944.

It seems to me that during the last two or three decades there have been all too few such clear expressions of opinion on this important subject as that given by Dr. Carlson in this article, which I note was first published in 1931. In the days of Huxley and his contemporaries such expressions of conviction were rather common, but since that time only occasionally has such an article appeared in an outstanding scientific magazine.

I am a very religious individual, but I am of the opinion that such articles as this do a great deal of good. Considering how large a proportion of human thought and emotions are concerned with the supernatural, it would seem to me that scientific literature might well devote more attention to it.

I hope that before long you will be able to publish another article on the same topic, by some scientist as eminent as Dr. Carlson, but taking some other point of view. Preferably the author should be a physiologist or biologist, because I note that Dr. Carlson is slightly suspicious of other types of scientists. I take it that his observations about the physicists, in the second column on page 94, were occasioned by some articles expressing a different point of view from his, which were appearing at about the time when he originally wrote this address.

I am sure that many others among your readers must have enjoyed, as I did, Dr. Carlson's excellent use of language, the clarity of his thinking, and the person to person attitude in which he expresses his convictions. I have never heard him speak, but at the end of the article I had a feeling as if I had been sitting in the hall listening to his lecture. It is true that he seems at times to offer as statements of fact what are merely expressions of opinion, and also that apparently he regards science as the only path to truth . . . which, of course, might even be so, or might not. But I found the article very inspiring reading, and cannot refrain from expressing my opinion that it, and other articles like it, make real contributions to human progress.—JAMES WATSON, M.D.

Is it the function of THE SCIENTIFIC MONTHLY to "front-page," as it were, sneering attacks on religion by eminent scientists? President Carlson has as much right to his opinion on these matters as anyone else, and as much right to defend those opinions, provided it is done in a rational rather than an emotional way, and with due respect for those of equal competence with himself who differ from him. But these saving characteristics are entirely lacking in the lecture which you reprint as the opener in the current issue of the MONTHLY. The address is a continuous succession of contemptuous slurs on religion. These come to a climax when the author condescendingly remarks: "the modern man of science has no essential quarrels with Jesus, ... They did the best they could, considering the ignorance of their times." Such a comment comes with a profound shock to the devout Christian reader, whether scientist or non-scientist. Has Dr. Carlson no respect for such of his fellow-scientists as Robert A. Millikan, Sir Arthur Eddington, Sir James Jeans, and many others, who are devout Christians as well as scientists, as conversant with scientific method as himself? It would have been far better if you had allowed this lecture to continue to gather dust in the files of *Science*, where it originally appeared, rather than to resurrect it in the pages of the MONTHLY. I hope very much you will ask some equally reputable scientist who does have some use for religion to present the other side of this question, in language more temperate than that of President Carlson. If I had the time I would be much tempted to do this myself at length, but I am afraid no science-proud scientist would pay much attention to the raving of a mere philosopher! And certainly, no professional theologian should enter the lists. But I am quite sincere in my expression of concern.—JARED S. MOORE.

If I err in my belief that the souls of men are immortal, I gladly err, nor do I wish this error, in which I find delight, to be wrested from me.—CICERO.

In reprinting "Science and the Supernatural" you have done the greatest service to all members and indirectly to all Americans.

For more than twenty years I have been reading the Monthly and I believe I have never written you before, but Dr. Carlson's article is so important I feel I must commend you for it.—HARRISON HIRES.

Some men of science show a regrettable tendency to comment adversely on the foundations of Christian Faith. Such questions lie without the scope of physical science, and no scientist known to me has contributed to our knowledge of the subject.

Without having polled them, I suspect that most teachers of science and those doing laboratory work for industry are Christians. But whether they are or not has no relation to their skill and achievements in scientific development. Study of physics and chemistry and biology and astronomy and geology does not even tend to qualify men to speak as experts on questions of evidence and historical criticism, which alone can determine whether the Bible is a revelation of the Infinite.

Few fields of research have been so fruitful in recent times as archeology. It has awakened dead civilizations and brought them into court with an impressive wealth of corroborative evidence from a source independent and hitherto unknown and so contributed more than physical science has to the greatest of all questions.

In his article on Science and the Supernatural, Dr. Anton J. Carlson seems to follow David Hume and others in saying a miracle is impossible and therefore not susceptible of proof by any testimony. But a physiologist is no better authority on that question than a mechanic. We all know that a miracle does not occur in the usual course of nature. If it did, it would not be a miracle and would be without significance.

But historians in general accept the Biblical narrative as true. The resurrection of Jesus is better authenticated than Caesar's invasion of Gaul. Its truth is a question of fact to be proved by evidence as we prove all questions of fact. Scientists will render a better service by keeping in fields of scientific research in which they have achieved so much.—GILBERT O. NATIONS.

The cry of the human for a life beyond the grave comes from that which is noblest in the soul of man.—HENRY VAN DYKE.

Dr. A. J. Carlson's superb article on "Science and the Supernatural" in the August issue is the best on the subject since Tyndall's famous Belfast address before the British Association.

The article to me, as a member of the Association, is worth many times the annual dues. It may give courage to others to smack supernaturalism and smack it hard, without offering any apologies.—WOOLSEY TELLER.

The article "Science and the Supernatural" in the August number of THE SCIENTIFIC MONTHLY lacks not only the necessary knowledge but also tact and reverence. It is insulting to realities which are sacred to me and to millions of other people. I have done scientific research in the field of biology, but I have never met a colleague who has lowered himself so far as to write the sort of incredible nonsense contained in the aforesaid article, which is an insult not only to religion but to science as well. I have learned to respect the opinions of others and I am able to tolerate ignorance so long as it is not associated with presumption, but I am completely unable and unwilling to respect the dogmas of a prophet of atheism.—P. B.

And will there, sometime, be another world? We have our dream. The idea of immortality, that like a sea has ebbed and flowed in the human heart, beating with its countless waves against the sands and rocks of time and fate, was not born of any creed, nor of any book, nor of any religion. It was born of human affection, and it will continue to ebb and flow beneath the mists and clouds of doubt and darkness, as long as love kisses the lips of death.—ROBERT G. INGERSOLL.

Just a word of congratulation for the brilliant article by Dr. A. J. Carlson on "Science and the Supernatural," appearing in the most recent issue of THE SCIENTIFIC MONTHLY.

We need a great deal more of such rational thinking.—AARON ADDELSTON.

I am frankly surprised that material of this sort should be accepted for publication in such a reputable scientific journal. I happen to be not only director of research but also a member of the Board of Trustees of a theological seminary, and I have a wide acquaintance among religious leaders of all sorts. I do not know of any reputable scholar, whether Protestant, Catholic, or Jew, who "believes in the supernatural." It seems to me that Dr. Carlson's thesis has about the same value as an attempt by a preacher to disprove certain scientific theories that

have not been held by scientific scholars for fifty years.

I do not agree with Dr. Carlson's definition of the scientific method which he says is "the rejection *in toto* of all non-observational and non-experimental authority in the field of experience." I would say that it is just as credulous to disbelieve in a thing without proof of its incorrectness as to believe in a thing that has not been proven. The scientific approach should imply an entirely open mind and should not reject anything "in toto" unless the rejection can be justified by observation or experiment.

Dr. Carlson confuses belief in the supernatural with religion. The two things are unrelated. It could probably be shown statistically that superstition is more prevalent among those who are not religious than among those who are. Dr. Carlson appears to know as little about religion as some theological scholars of my acquaintance know about science. These theological scholars will read the article with considerable amusement.—EUGENE AYERS.

So live, that when the summons comes to join
The innumerable caravan which moves
To that mysterious realm, where each shall take
His chamber in the silent halls of death,
Thou go not, like the quarry-slave at night,
Scourged to his dungeon, but, sustained and soothed
By an unfaltering trust, approach thy grave,
Like one that wraps the drapery of his couch
About him, and lies down to pleasant dreams.

—WM. CULLEN BRYANT

Would it be possible to secure additional copies of the paper in the August issue of THE SCIENTIFIC MONTHLY by Dr. Carlson? It states the situation so clearly and so forthrightly that I should like to be able to circulate it widely among my sociology students.—FRANK H. HANKINS.

It was pleasant to see Professor Carlson's "Science and the Supernatural" in your August issue and still more pleasant to find out that a man of his type can be elected president of the Association.—B. F. JAKOBSEN.

Dr. Carlson triumphantly proves in his article in the August number that the supernatural is not the natural and therefore not amenable to the scientific method. When he goes further and suggests that therefore it does not exist, he departs from the scientific method and uses supernatural methods just as much as if he killed a goat.—J. EDGAR PARK.

O may I join the choir invisible
Of those immortal dead who live again
In minds made better by their presence.

—GEORGE ELIOT

I think the title Science and the Supernatural is a misnomer as applied to Dr. Carlson's article. It could better have been called Science and Religion.

Now let's have an article by him: Science and the Extra-Religious Supernatural as an answer to Reading Your Mind in the August *Atlantic* and to that very interesting article in the July *Readers' Digest* about a Spiritualist of the early 19th century.—RUTHERFORD FULLERTON.

The article by A. J. Carlson in THE SCIENTIFIC MONTHLY was very decidedly offensive to me because of its gross materialism. I cannot believe it represents science.—S. G. B.

And now abideth faith, hope, charity, these three; but the greatest of these is charity.—I Corinthians, XIII, 13.